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SUBSONIC LONGITUDINAL AND LATERAL-DIRECTIONAL STATIC AERODYNAMIC CHARACTERISTICS FOR A MODEL WITH SWEPT BACK AND SWEPT FORWARD WINGS

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ABSTRACT

A general research fighter model was tested in the Langley 7- by 10-foot high speed tunnel at a Mach number of 0.3. With a conventional empennage, the model was tested with the wing in a 60° swept back configuration and in a 32° swept forward configuration. The 32° swept forward configuration was also tested with a strake. Very limited data was obtained with a wing in a 50° swept back configuration and in a 7° swept forward configuration. The angle-of-attack range was from approximately -4° to 48° at sideslip angles of 0°, -5°, and 5°. The data are presented without analysis in order to expedite publication.

INTRODUCTION

In the late 1940's, as aircraft speeds were approaching Mach one, investigations were conducted to evaluate swept forward and swept back wings as a means of delaying the onset of transonic compressibility effects. (See reference 1-3). Sweeping the wings, either forward or back, delayed the drag rise to a higher Mach number; however, an aeroelastic divergence problem was found to be associated with swept forward wings. (See references 4 and 5). This structural instability problem could be eliminated, but the resulting swept forward wing was significantly heavier than a corresponding swept back wing. As a consequence of this fact, most of the subsequent research was concentrated on swept back wings.

Recently, research interest in forward sweep has been renewed. This is partly a result of studies, such as reference 6, which indicate that proper tailoring of composite materials can produce a swept forward wing with minimal weight penalty. Forward sweep is being studied in relation to a variety of configurations. When applied to fighter aircraft, the forward sweep concept offers the potential for improved subsonic and supersonic cruise performance as well as improved transonic maneuver performance.

Experimental studies have been initiated to expand the existing data base on swept forward wings. (See reference 7.) The present study was conducted to obtain the static aerodynamic characteristics of a model with a conventional empennage and with swept back and swept forward wing configurations. The 32° swept forward wing was also tested with a strake.

It should be noted that the models were built up from wing model parts previously constructed for swept back configurations. These wings had circular arc airfoil sections which allowed their use in the reversed or forward sweep condition. It should be also noted that, because of the flow separation at the sharp leading edges, the present data will be generally more applicable to the study of the high angle-of-attack characteristics.

The tests were performed in the Langley 7- by 10-foot speed tunnel at a Mach number of 0.3. The angle-of-attack range was from approximately -4° to 48° at sideslip angles of 0°, -5°, and 5°-

SYMBOLS

The International System of Units, with the U.S. Customary Units presented in parenthesis, is used for the physical quantities in this report (See reference 8). The measurements and calculations were made in the U.S. Customary Units. The data presented in this report are referred to the stability axis system. The reference center for moments is shown in Figure 1(a).

b wing reference span, .508m (20.000 in.)

$\bar{c}$ wing reference chord, .233 m (9.185 in.)

C_D drag coefficient, $\frac{\text{Drag}}{qS}$

C_L lift coefficient, $\frac{\text{Lift}}{qS}$

C_ℓ rolling moment coefficient, $\frac{\text{Rolling moment}}{qSb}$

C_{ℓ_β} beta derivative of rolling moment coefficient computed between $\beta = 5^\circ$ and $\beta =-5^\circ$

C_m pitching moment coefficient, $\frac{\text{Pitching moment}}{qS\bar{c}}$

C_n yawing moment coefficient, $\frac{\text{Yawing moment}}{qSb}$

C_{n_β} beta derivative of yawing moment coefficient computed between $\beta = 5^\circ$ and $\beta = -5$

C_Y side force coefficient, $\frac{\text{Side force}}{qS}$

C_{Y_β} beta derivative of side force coefficient computed between $\beta = 5^\circ$ and $\beta = -5^\circ$

M free stream Mach number

q free stream dynamic pressure, Pa (lb/ft^2)

S wing reference area, .1032 m^2 (1.11109 ft^2)

X axial distance from exposed strake theoretical apex (see figure 1(d))

Y local exposed span of strake (see Figure 1(d))

α angle of attack, degrees

β angle of sideslip, degrees

Λ_w leading edge sweep angle of the wing, degrees

Model

B body

H horizontal tail

S strake

V vertical tail

W wing

DESCRIPTION OF THE MODEL

Drawings of the model tested are presented in Figure 1. Photographs of the model installed in the 7- by 10-foot high speed tunnel are presented in Figure 2. The basic model consisted of a fuselage with a wing and horizontal and vertical tails. The fuselage was sting mounted on a six-component strain gage balance.

The uncambered, untwisted wings and horizontal and vertical tails employed circular arc airfoil sections with a thickness ratio of 6% at the fuselage juncture and 4% at the tip. The primary wing tested had one edge with a nominal sweep of 60° and one edge with a nominal sweep of 32° (See Figures 1(a), (b), (c)). This wing could be set up in either a 60° swept back leading-edge configuration or a 32° swept forward leading-edge configuration. The other wing tested had one edge with a nominal sweep of 50° and one edge with a nominal sweep of 7°. This wing could be set up in either a 50° swept back leading-edge configuration or a 7° swept forward leading-edge configuration.

A strake was tested in combination with the 32° swept forward wing. The strake consisted of a sharp edged flat plate (See Figure 1(d)). The exposed area of the strake was 5.4 percent of the wing reference area.

The horizontal tail, which is shown in Figure 1(e), had an exposed area of 28 percent of the wing reference area. The centerline mounted vertical tail, which is shown in Figure 1(f), had an exposed area of 15.3 percent of the wing reference area.

APPARATUS, TESTS, AND CORRECTIONS

The investigation was conducted in the Langley 7- by 10-foot high speed tunnel (See reference 9). Forces and moments were measured on a six component strain gage balance mounted internally in the model. The test was run at a Mach number of 0.3, corresponding to a Reynolds number of 1.4×10^6 based on the wing reference chord. The model was tested over an angle-of-attack range from $-4°$ to approximately $48°$ at sideslip angles of $0°$ and $\pm 5°$. The angles of attack and sideslip have been corrected for the effects of sting and balance bending under aerodynamic load. It should be noted that the sting support system which permits testing over this large angle range is designed specifically for stability testing. Therefore, the level of the drag data is questionable for use in performance analysis.

Jet boundary and blockage corrections have been applied to the data based on references 10 and 11, respectively. The balance chamber pressure was measured and the drag measurements were adjusted to a condition of free stream static pressure acting over the base of the model. Transition strips 0.16 cm (.0625 in.) in width of No. 120 Carborundum grams were placed 2.54 cm (1.0 in.) aft of the leading edge of the wings, strake, horizontal tail, and vertical tail as well as 3.05 cm (1.2 in.) aft of the nose of the fuselage (reference 12).

PRESENTATION OF RESULTS

The results are presented without analysis in order to expedite publication. Figure 3 presents surface oil flow photographs.

The longitudinal and lateral-directional aerodynamic characteristics at 0° sideslip are presented in the following figures:

	Figure
Swept back configuration.	4
Swept forward configuration:	
Strake off	5
Strake on	6
Effect of sweep	7

The lateral-directional aerodynamic stability derivative characteristics are presented in the following figures:

Swept back configuration	8
Swept forward configuration	
Strake off	9
Strake on	10

REFERENCES

1. Wright, J. B., and Loving, D. L., High Speed Wing Tunnel Tests of 1/16-Scale Model of the D-558 Research Airplane, NACA RM L6J09, 1947.

2. Whitcomb, R. T., An Experimental Study at Moderate and High Subsonic Speeds of the Flow over Wings with 30° and 45° of Sweep-Forward in Conjunction with a Fuselage, NACA RM L50K28, 1950.

3. Whitcomb, R. T., An Experimental Study at Moderate and High Subsonic Speeds of the Flow over Wings with 30° and 45° of Sweep-Back in Conjunction with a Fuselage, NACA RM L50K27, 1951.

4. Diederick, F. W.; and Budiansky, B.: Divergence of Swept Wings, ACA Technical Note 1680, 1948.

5. Bisplinghoff, R. L.; and Ashley, H.: Principles of Aeroelasticity, John Wiley and Sons, Inc., New York, 1962.

6. Krone, N. J., Lt. Col., Divergence Elimination with Advanced Composites, AIAA Paper No. 75-1009, Aircraft Systems and Technology Meeting, Los Angeles, California, August 1975.

7. Huffman, Jarrett K., and Fox, Charles H., Jr.: Subsonic Longitudinal and Lateral-Directional Static Aerodynamic Characteristics for a Close-coupled Wing-Canard Model in Both Swept Back and Swept Forward Configurations NASA TM-74092, 1978.

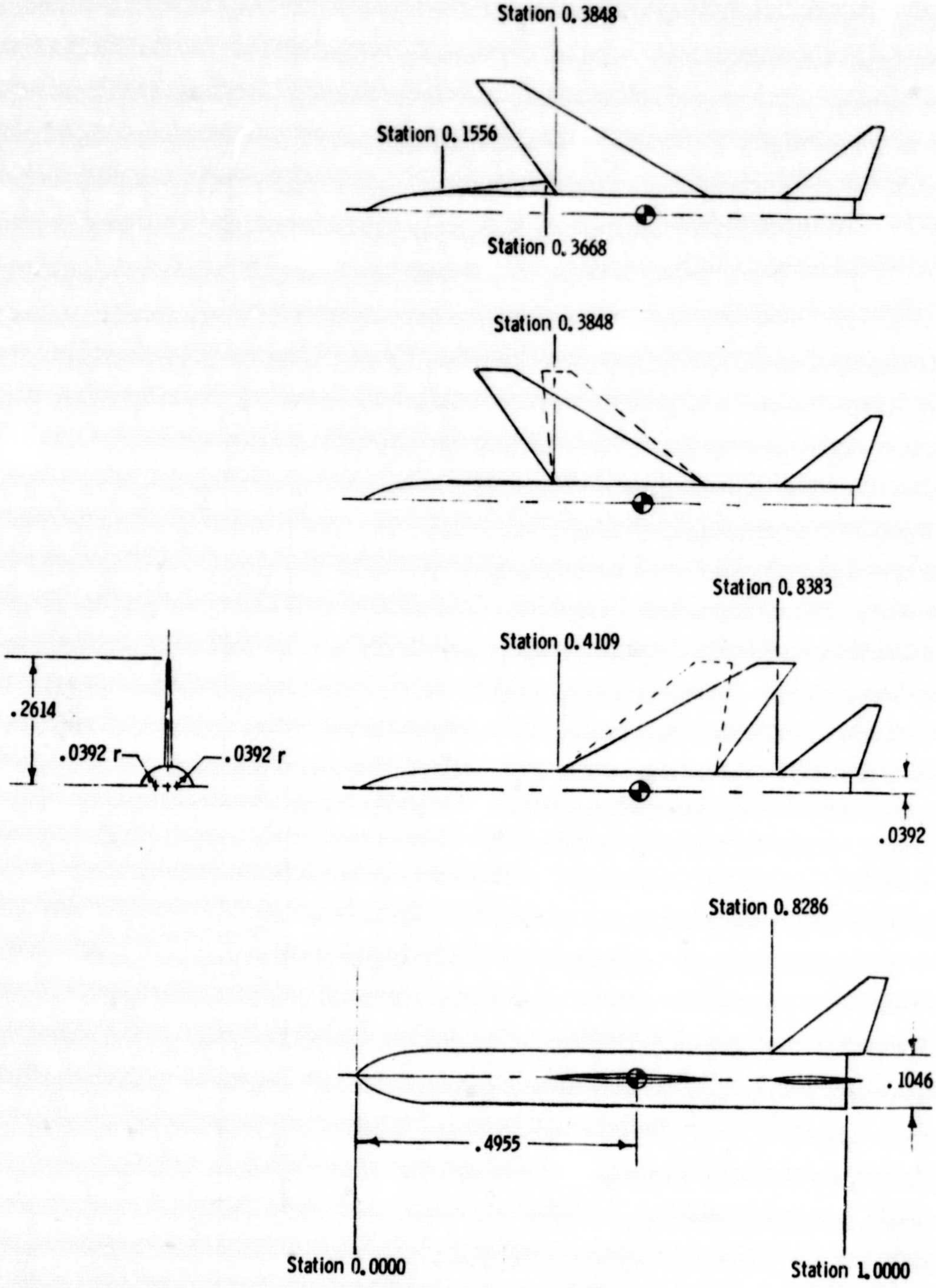
8. Mechtly, E. A.: The International System of Units. NASA SP-7012, 1964.

9. Fox, Charles H., Jr., and Huffman, Jarrett K.: Calibration and Test Capabilities of the Langley 7- by 10-foot High Speed Tunnel. NASA TM X-74027, 1977.

10. Gillis, Clarence L.; Polhamus, Edward C., and Gray, Joseph L., Jr.: Charts for Determining Jet-Boundary Corrections for Complete Models in 7- by 10-foot Closed Rectangular Wind Tunnels. NACA WR-L-123, 1945.

11. Herriott, John G.: Blockage Corrections for Three-Dimensional-Flow Closed-Throat Wind Tunnels, with Consideration of the Effect of Compressibility. NACA Report 995, 1950.

12. Braslow, Albert L.; Hicks, Raymond M., and Harris, Roy V., Jr.: Use of Grit-type Boundary-layer Transition Trips on Wind Tunnel Models. NASA TN D-3579, 1966.



(a) General arrangement.

Figure 1. Drawings of the model tested. All dimensions are normalized by a fuselage length of 0.97155 m. (38.25 in.)

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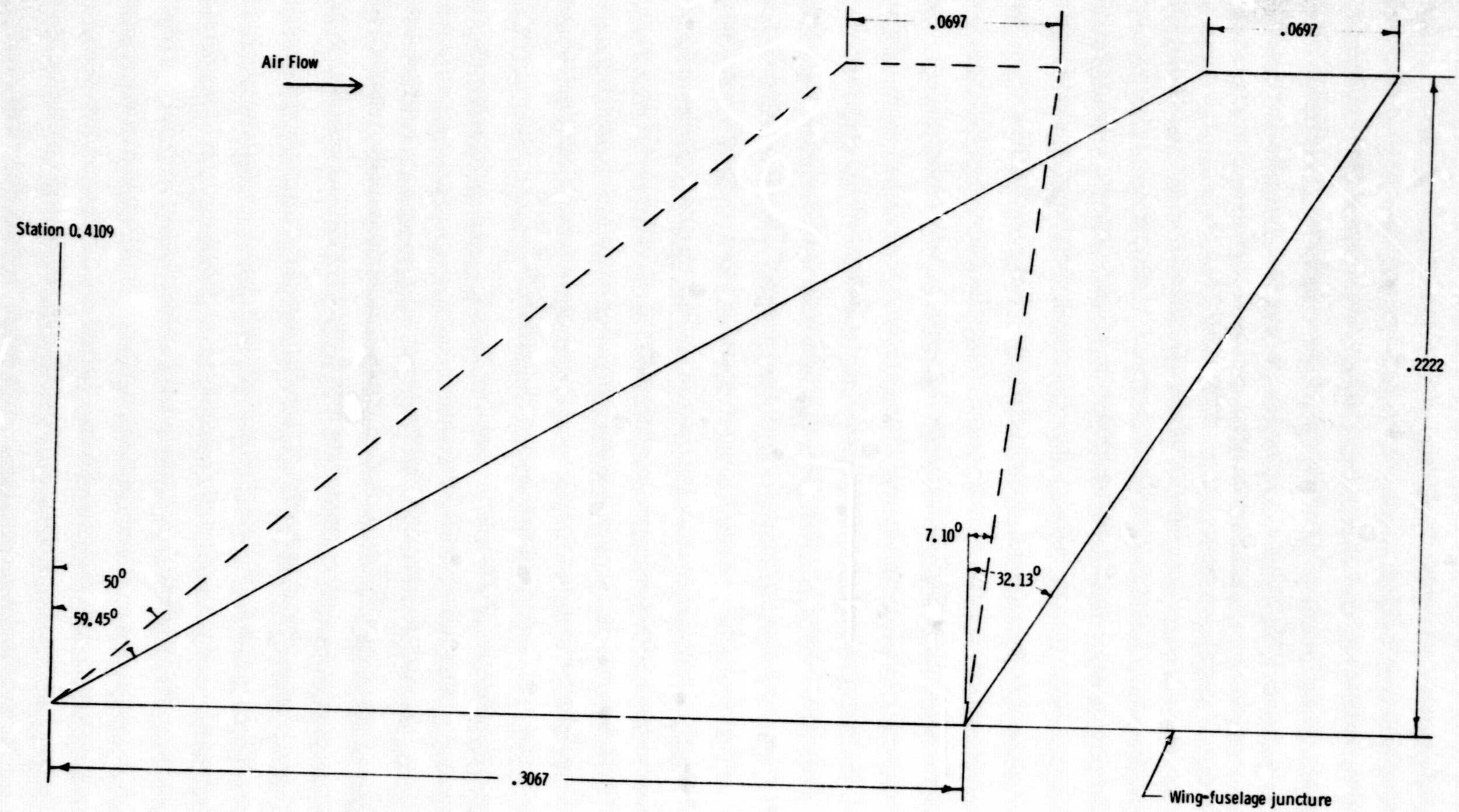
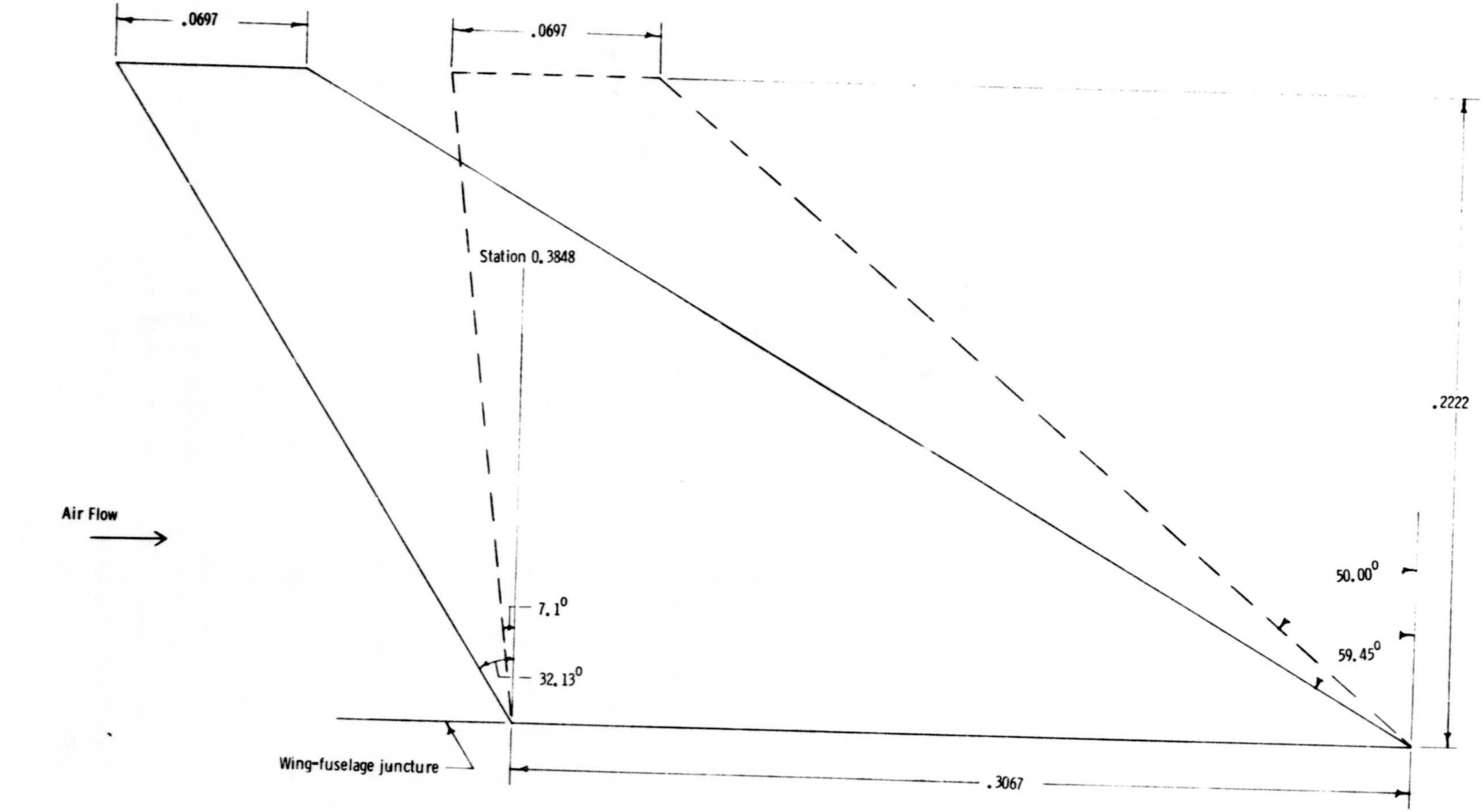


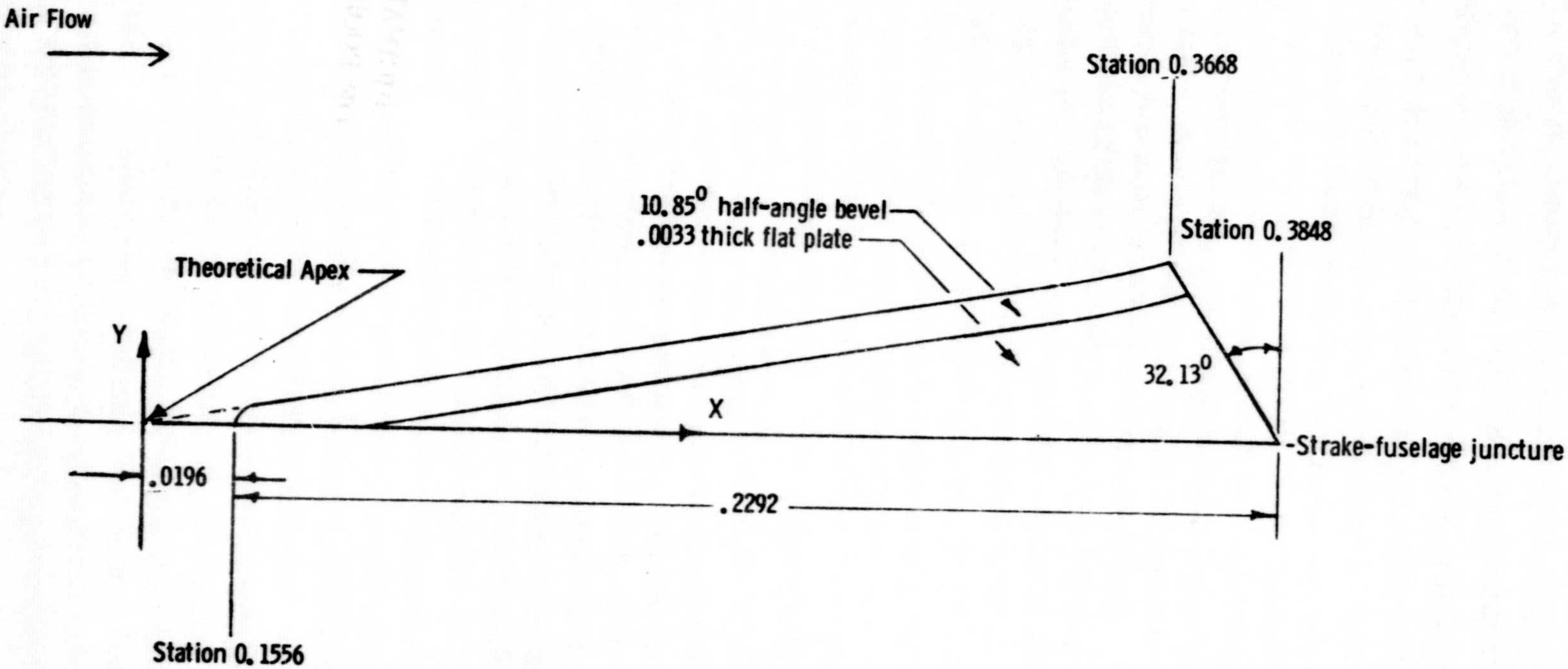
(b) Details of the swept back wings.

Figure 1. Continued.



(c) Details of the swept forward wings.

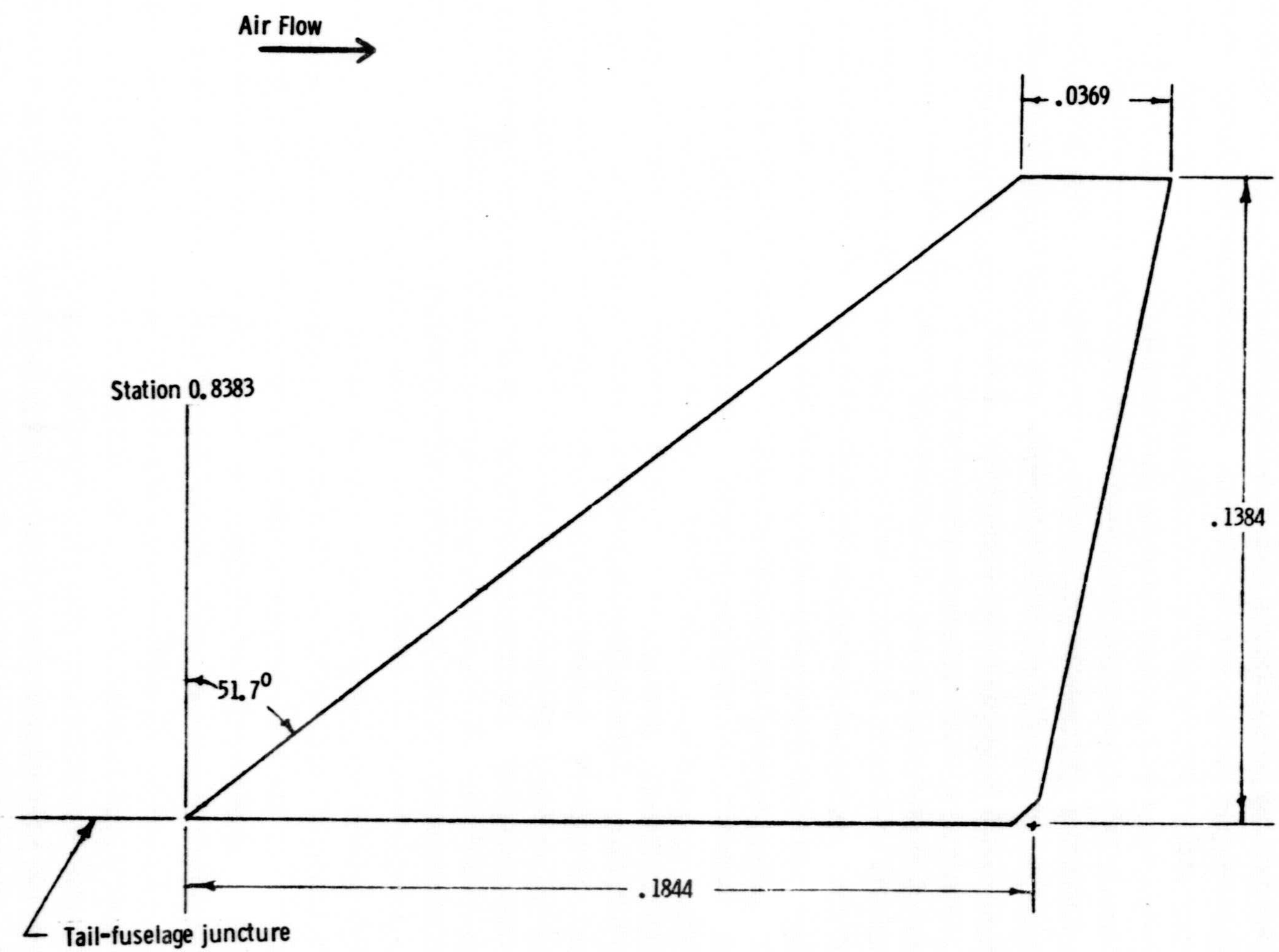
Figure 1. Continued.



X	Y
0.0000	0.0000
0.1961	0.0222
0.2092	0.0239
0.2222	0.0261
0.2353	0.0288
0.3007	0.0421

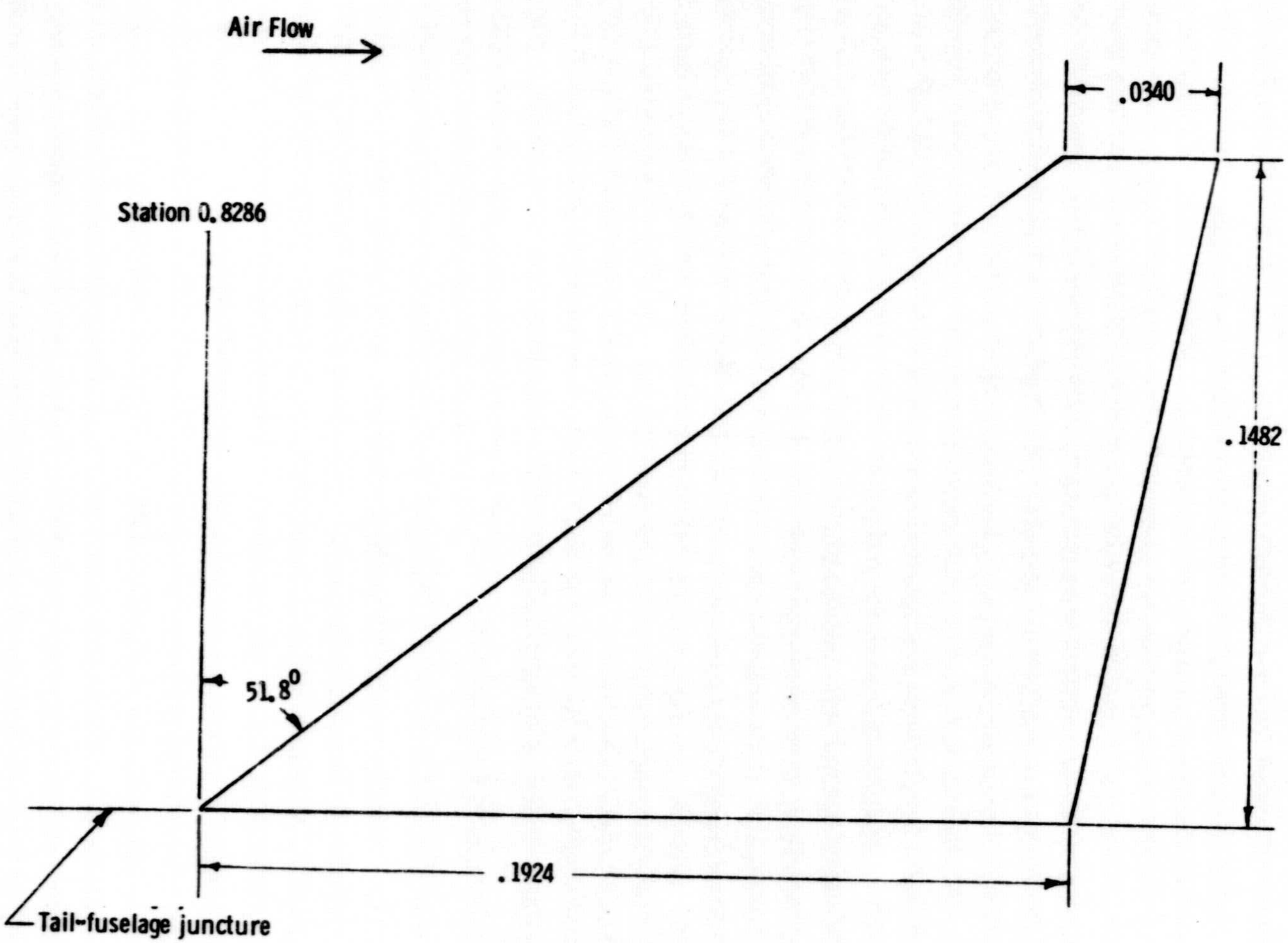
(d) Details of the strake.

Figure 1. Continued.



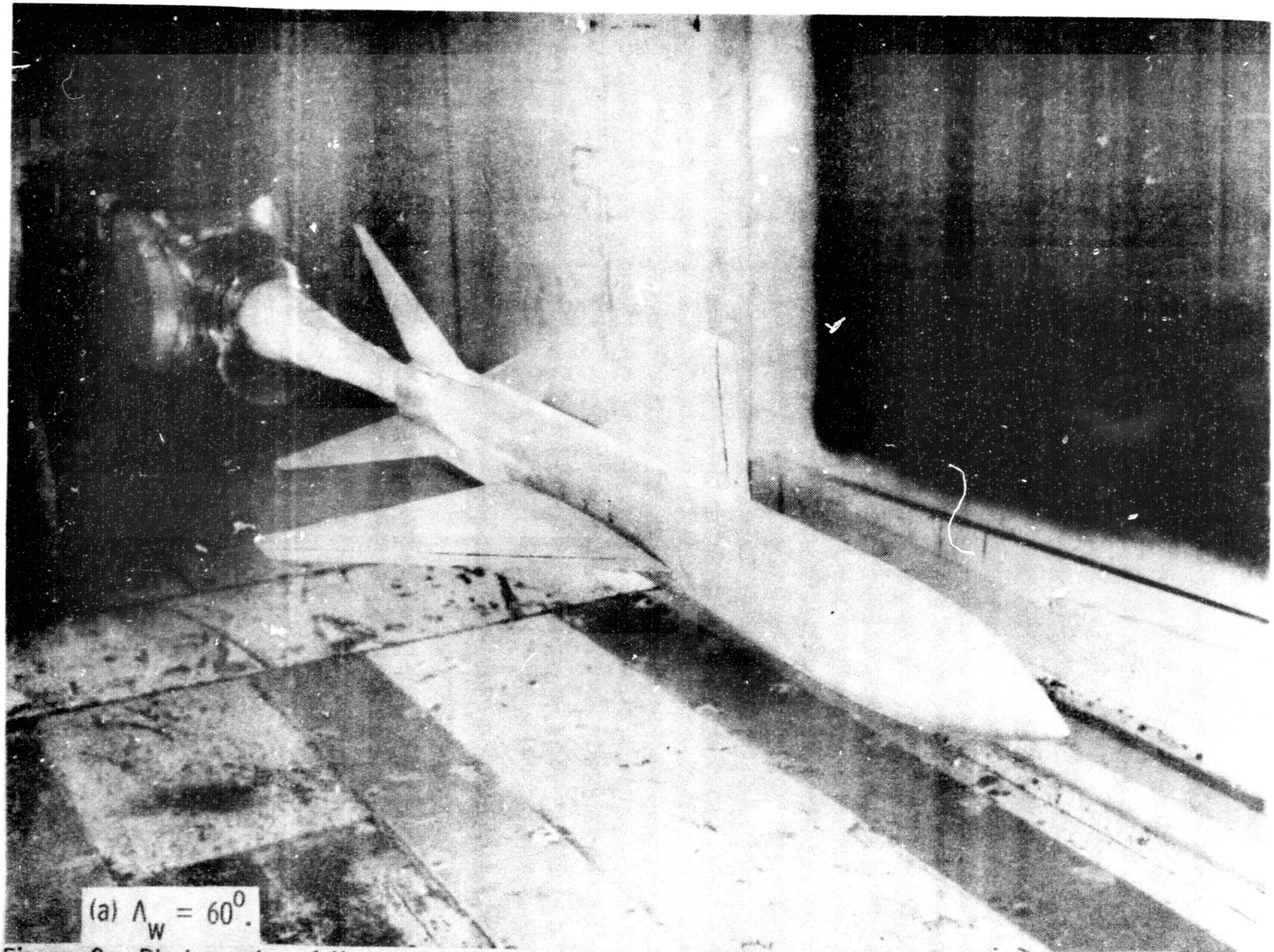
(e) Details of the horizontal tail.

Figure 1. Continued.



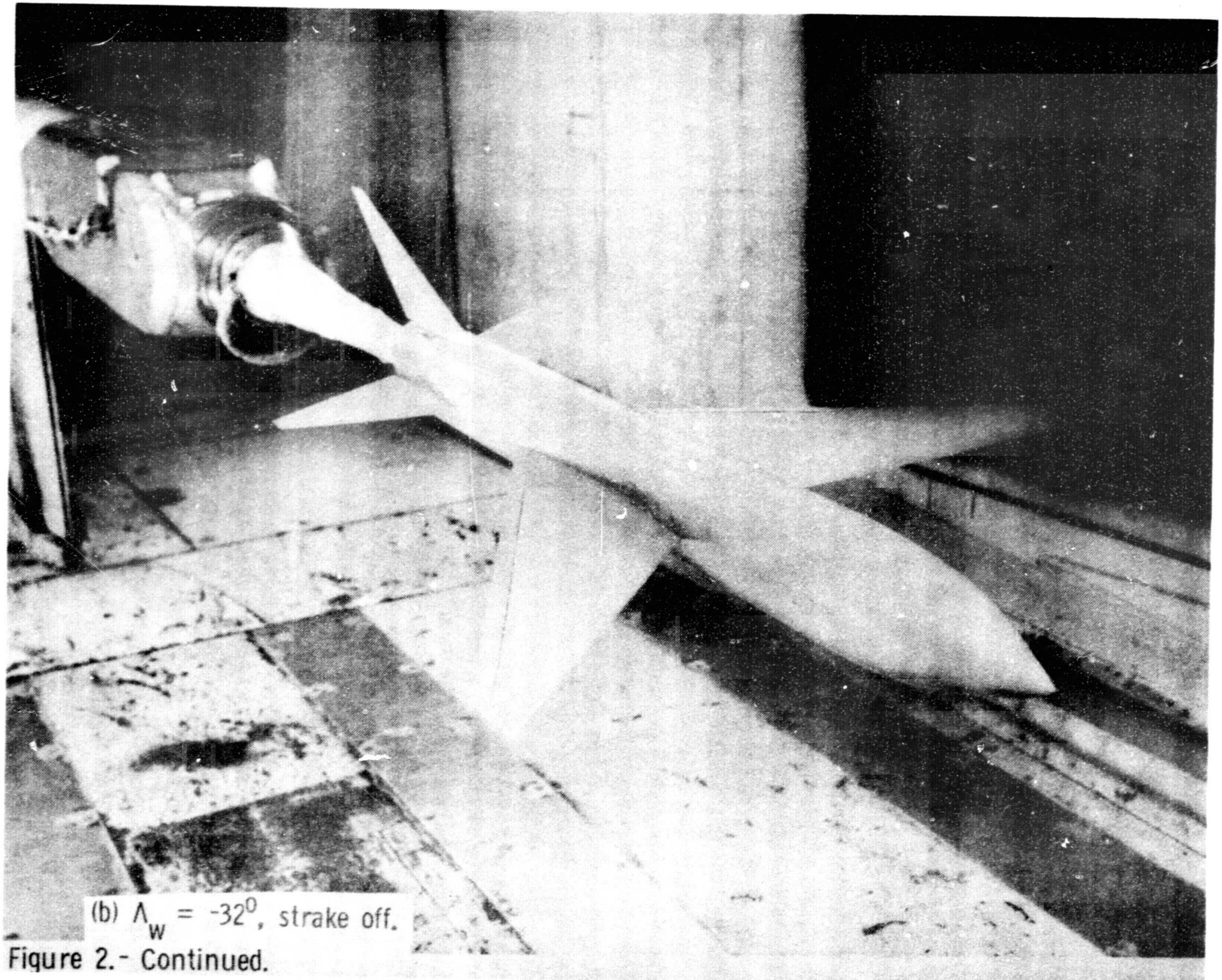
(f) Details of the vertical tail

Figure 1. Concluded.



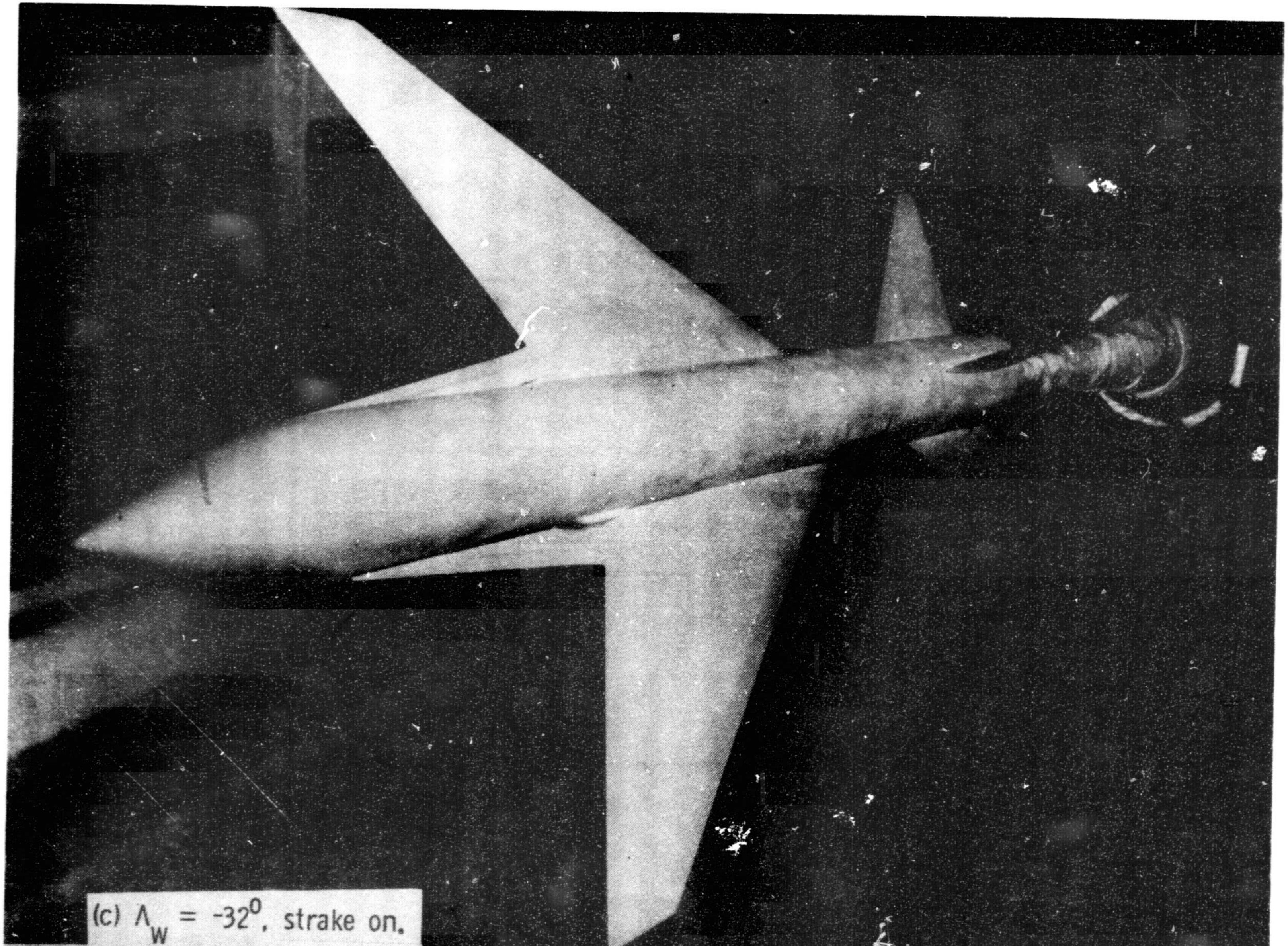
(a) $\Lambda_w = 60^0$.

Figure 2.- Photographs of the model installed in the Langley 7- by 10-foot high speed tunnel.



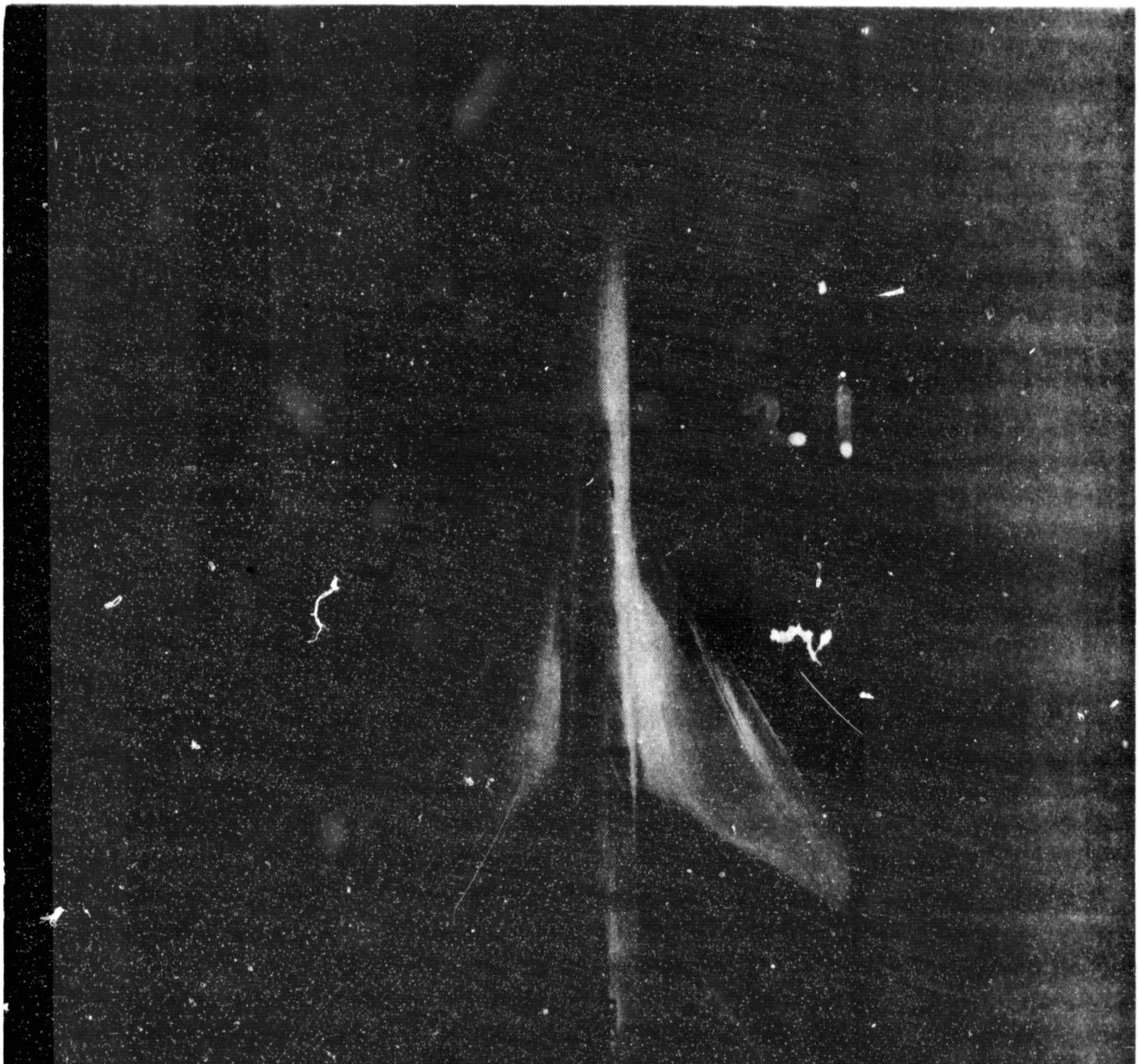
(b) $\Lambda_w = -32^0$, strake off.

Figure 2.- Continued.



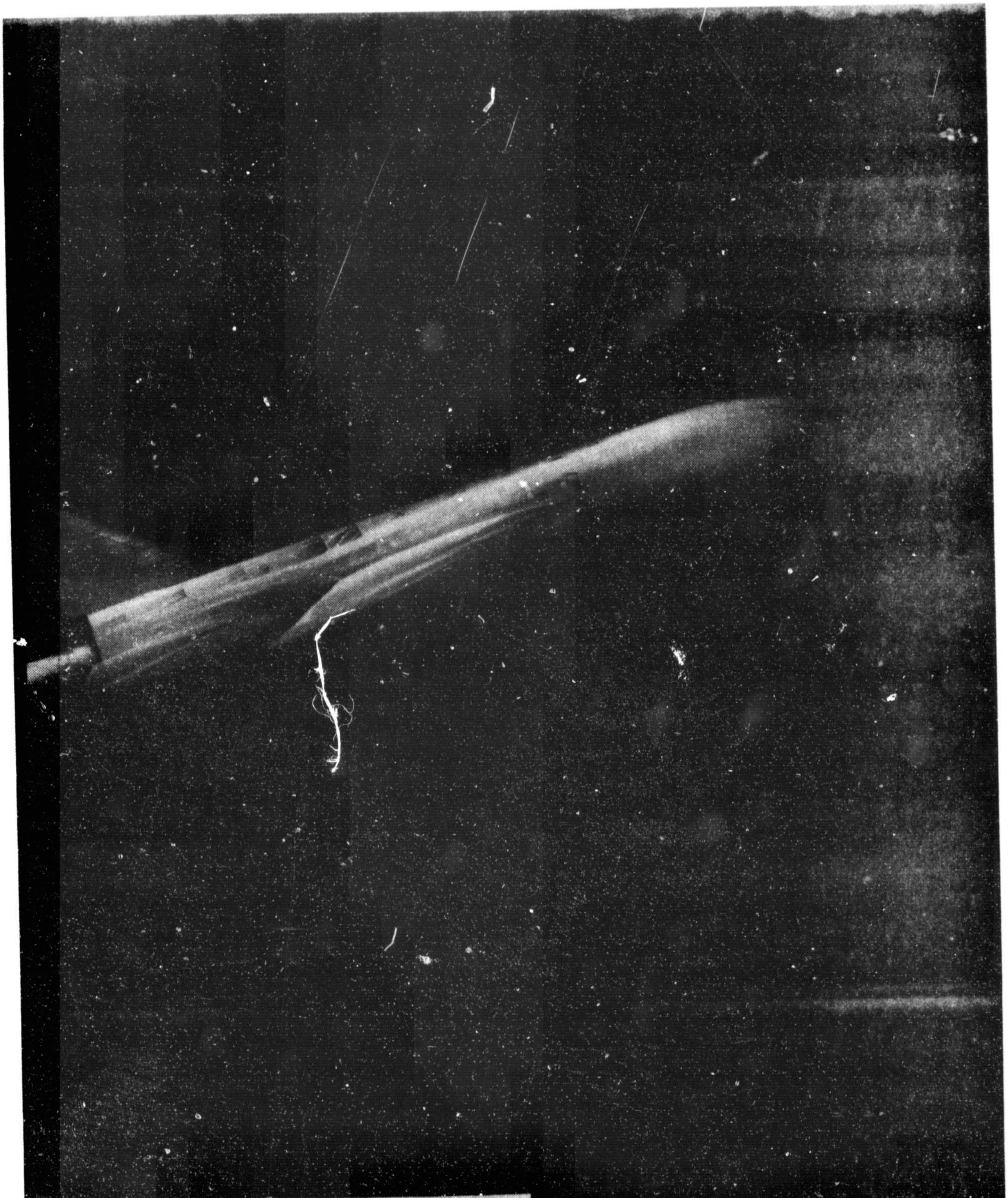
(c) $\Lambda_w = -32^0$, strake on.

Figure 2.- Concluded.



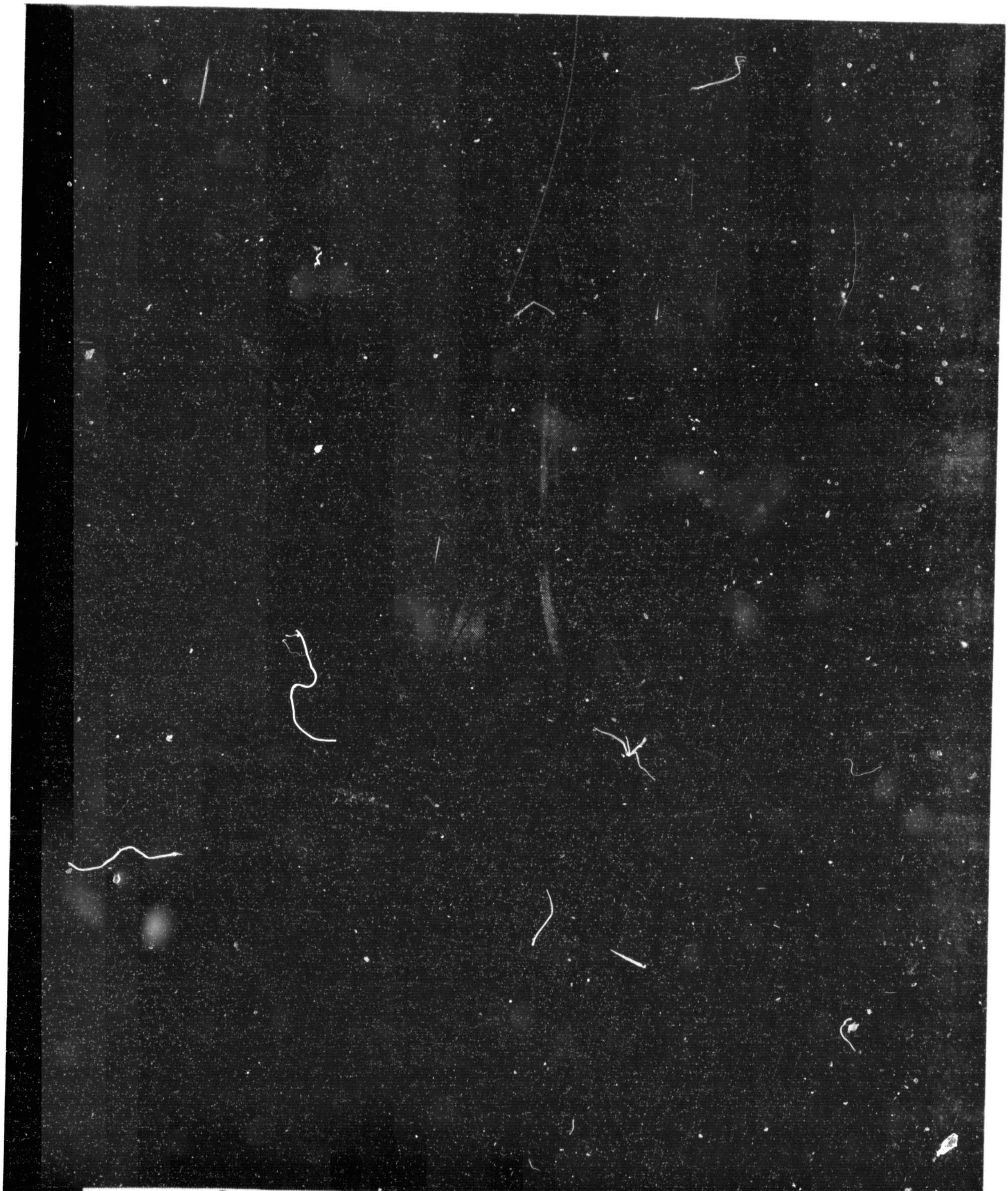
(a) $\alpha = 15^0$, $\Lambda_w = 60^0$, plan view.

Figure 3.- Surface oil flow photographs. $M = 0.3$.



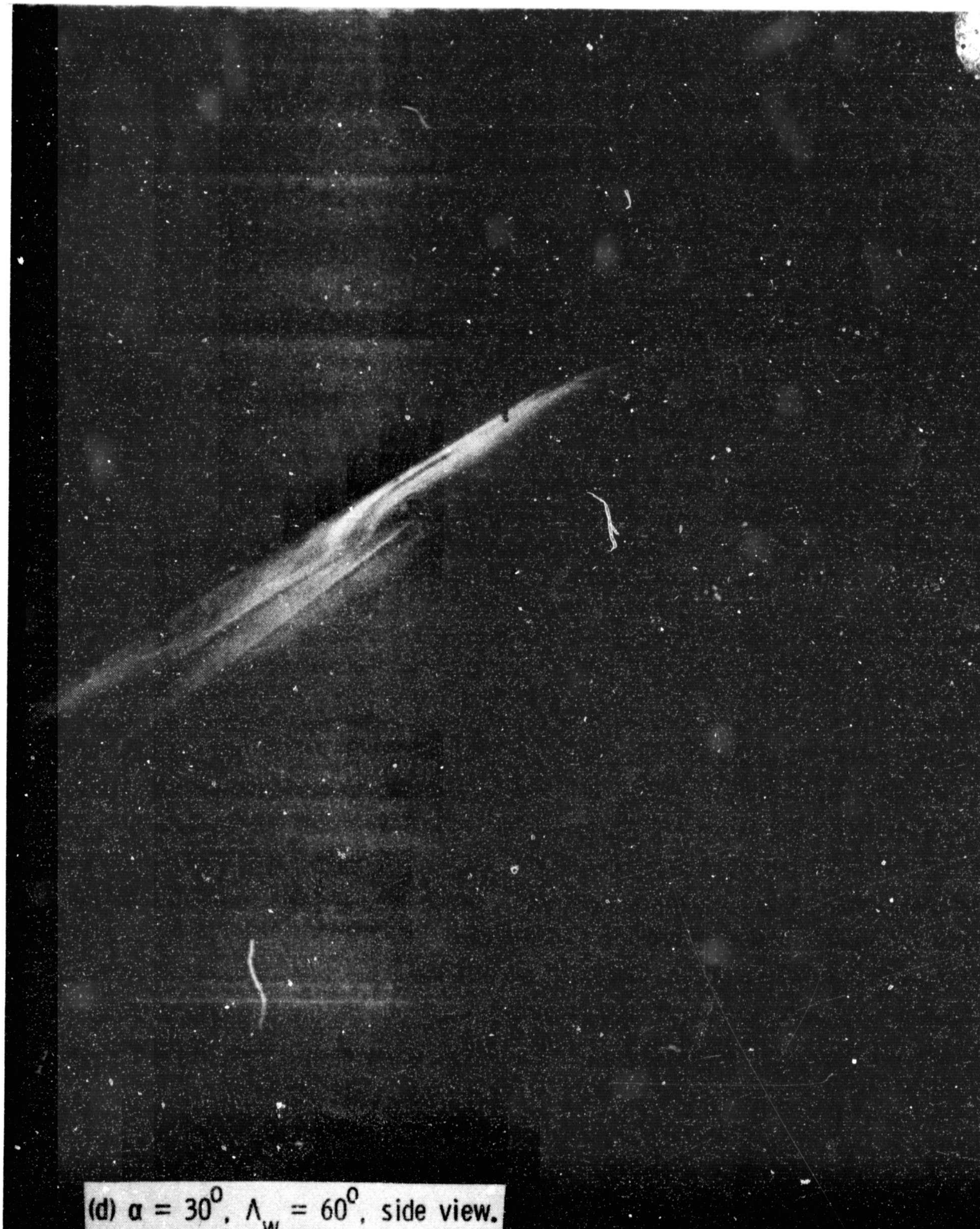
(b) $\alpha = 15^0$, $\Lambda_W = 60^0$, side view.

Figure 3.- Continued.



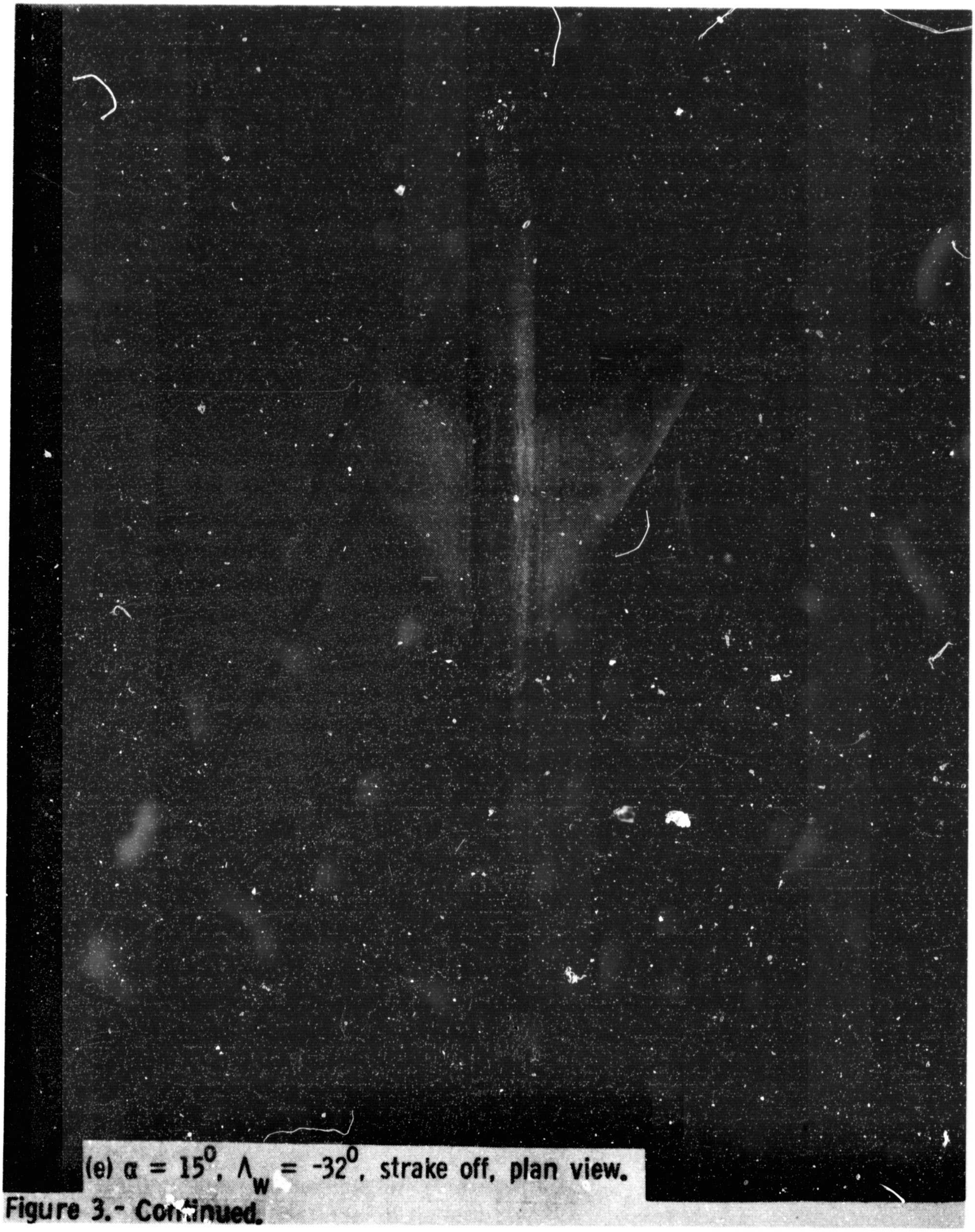
(c) $\alpha = 30^0$, $\Lambda_W = 60^0$, plan view.

Figure 3.- Continued.



(d) $\alpha = 30^{0}$, $\Lambda_{W} = 60^{0}$, side view.

Figure 3.- Continued.



(e) $\alpha = 15^{0}$, $\Lambda_{w} = -32^{0}$, strake off, plan view.

Figure 3.- Continued.

(f) $\alpha = 15^0$, $\Lambda_W = -32^0$, strake off, side view.

Figure 3.- Continued.

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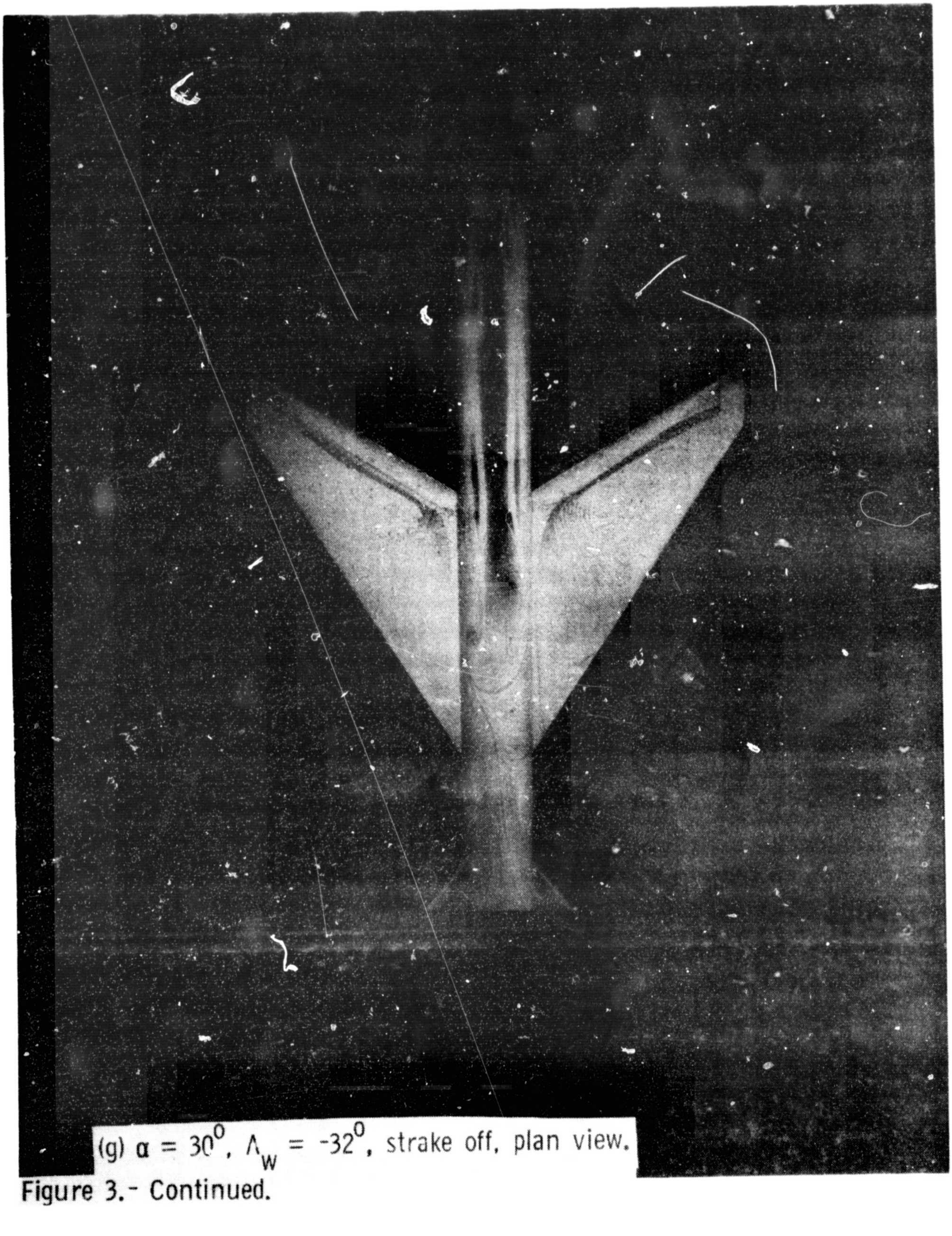

(g) $\alpha = 30^0$, $\Lambda_W = -32^0$, strake off, plan view.

Figure 3.- Continued.

(h) $\alpha = 30^{\circ}$, $\Lambda_{W} = -32^{\circ}$, strake off, side view.

Figure 3.- Continued.

(i) $\alpha = 15^0$, $\Lambda_w = -32^0$, strake on, plan view.

Figure 3.- Continued.

(j) $\alpha = 15^0$, $\Lambda_w = -32^0$, strake on, side view.

Figure 3. - Continued.

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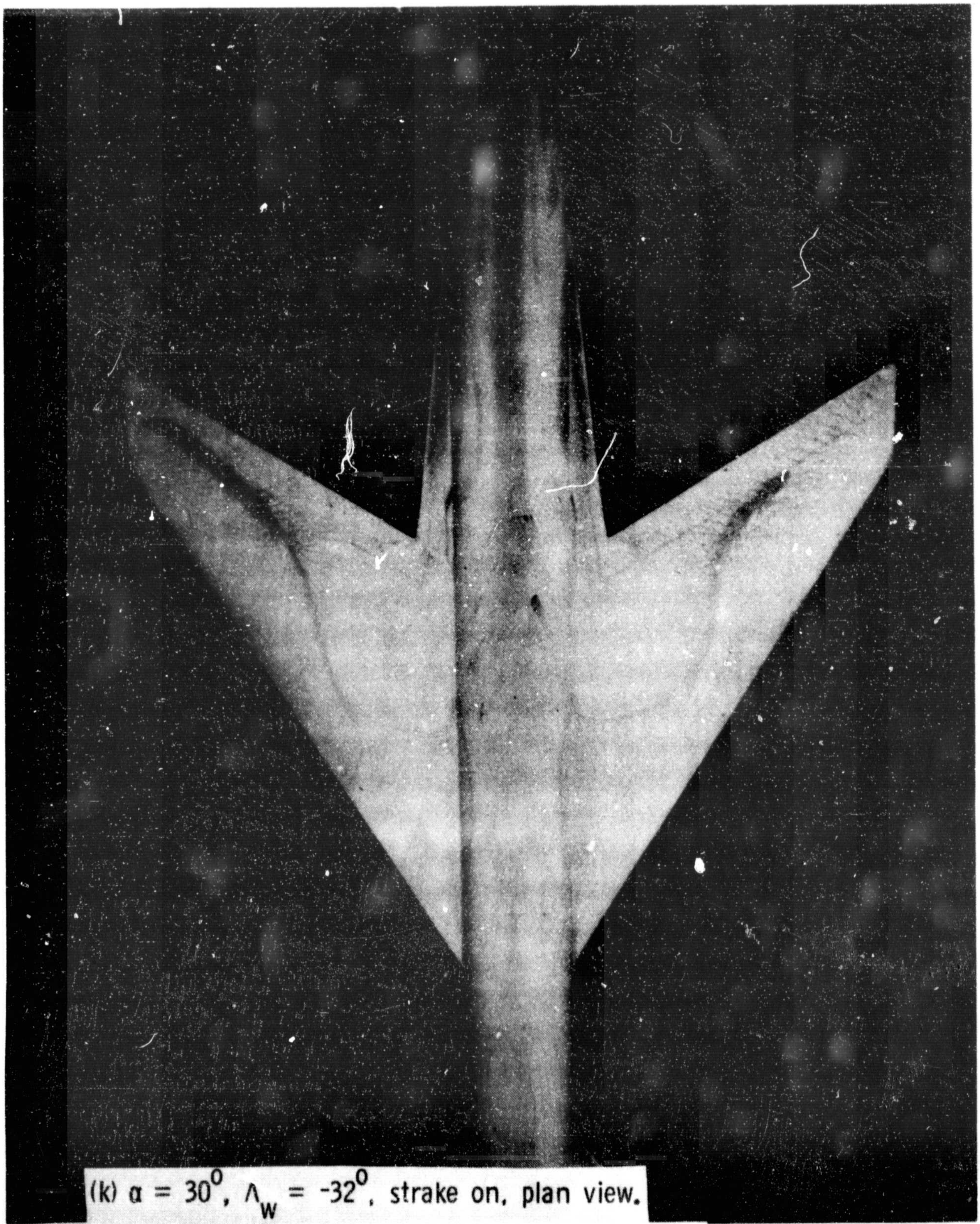
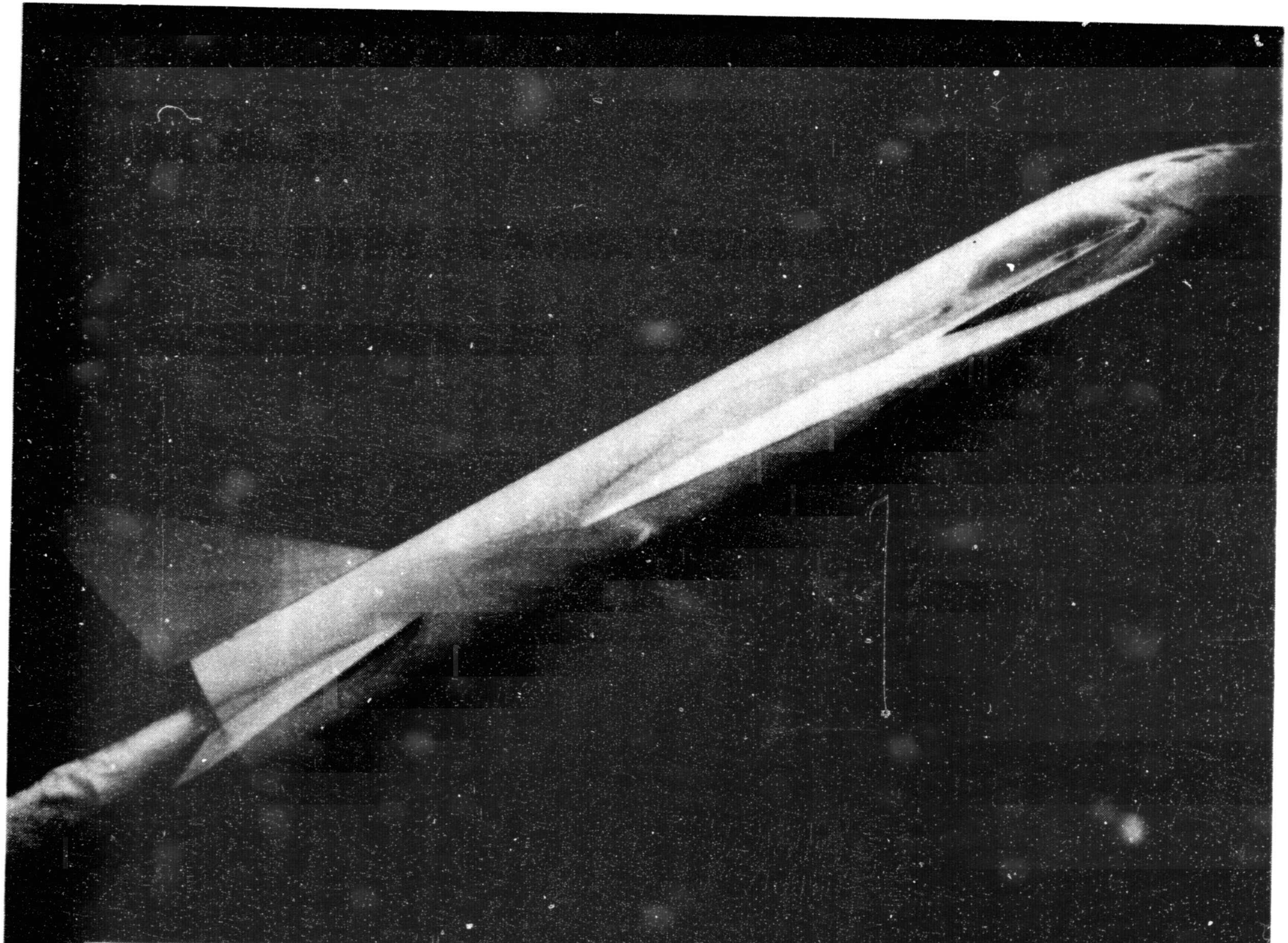


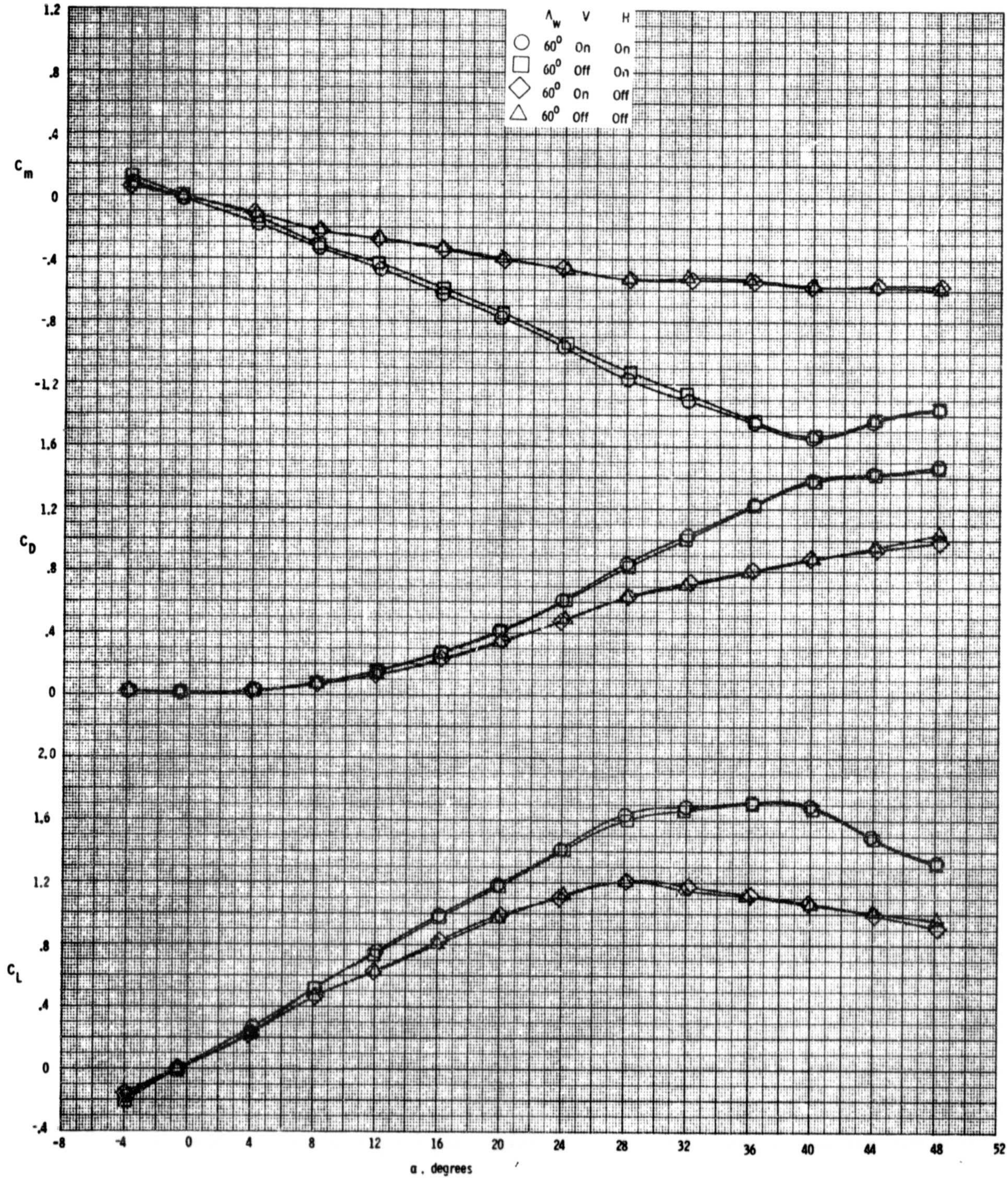
(k) $\alpha = 30^{\circ}$, $\Lambda_{w} = -32^{\circ}$, strake on, plan view.

Figure 3.- Continued.



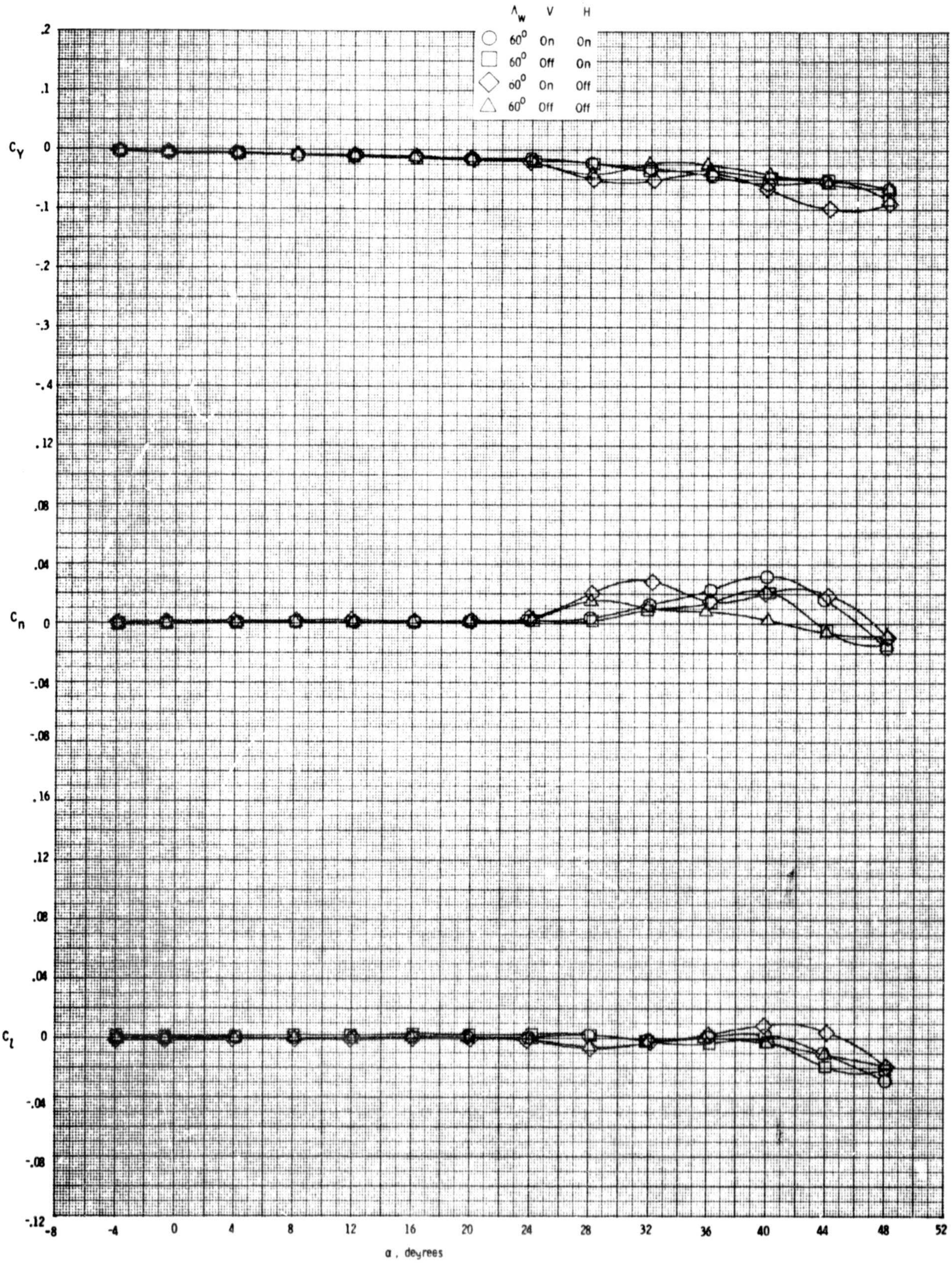
(l) $\alpha = 30^0$, $\Lambda_W = -32^0$, strake on, side view.

Figure 3.- Concluded.



(a) Longitudinal characteristics

Figure 4. Characteristics of the swept back configuration. $M = 0.3$, $\beta = 0^0$.



(b) Lateral-directional characteristics
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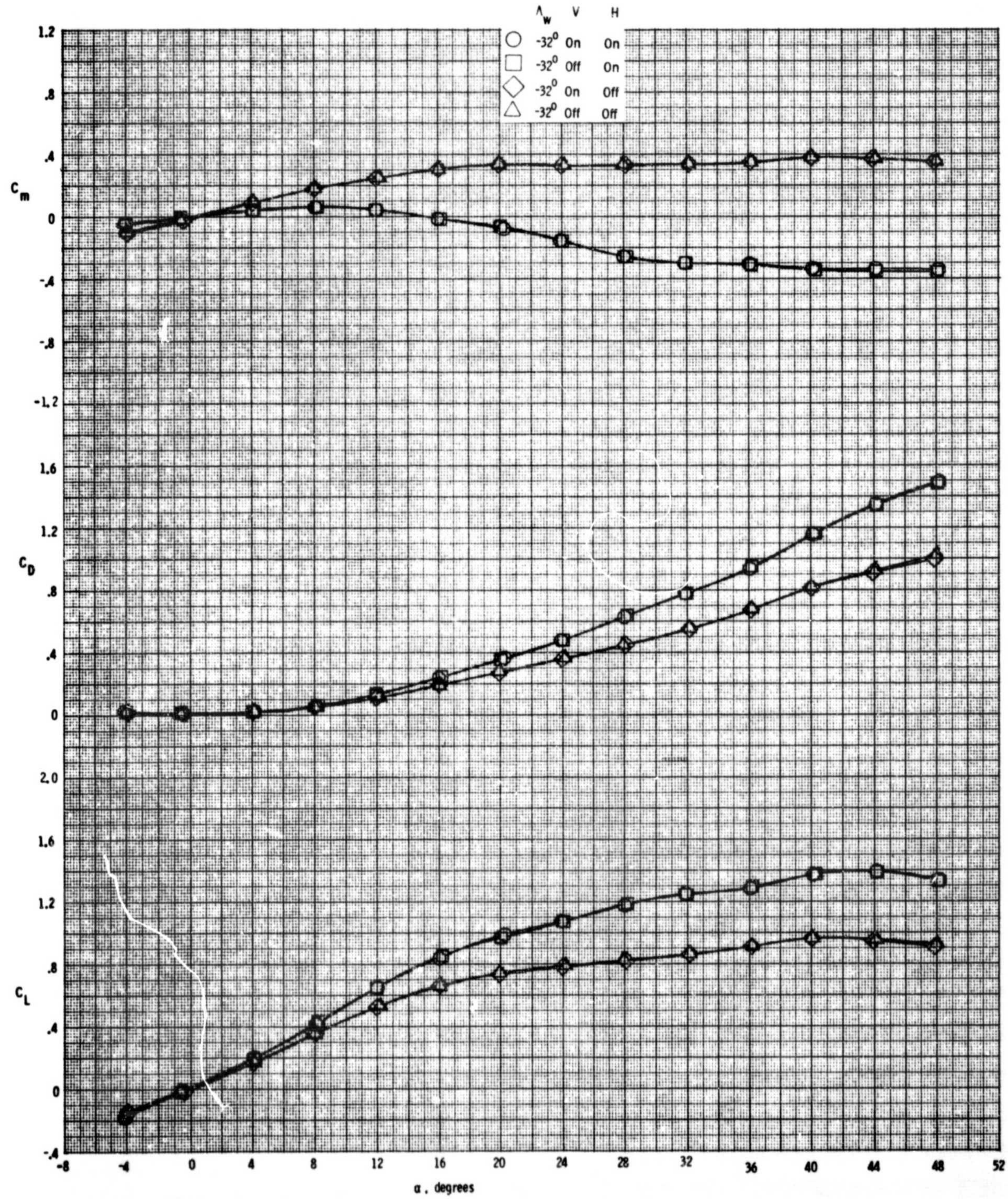
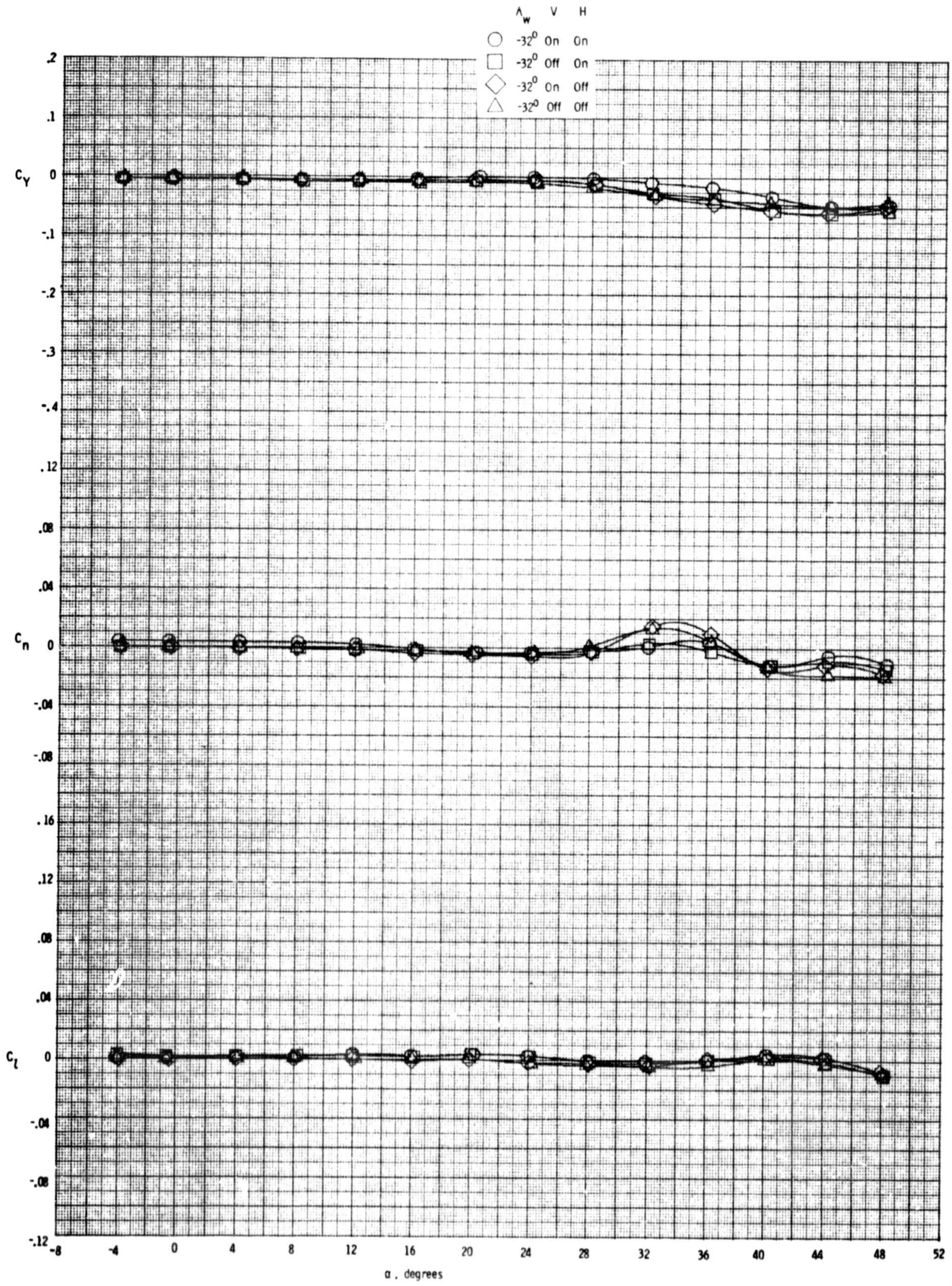


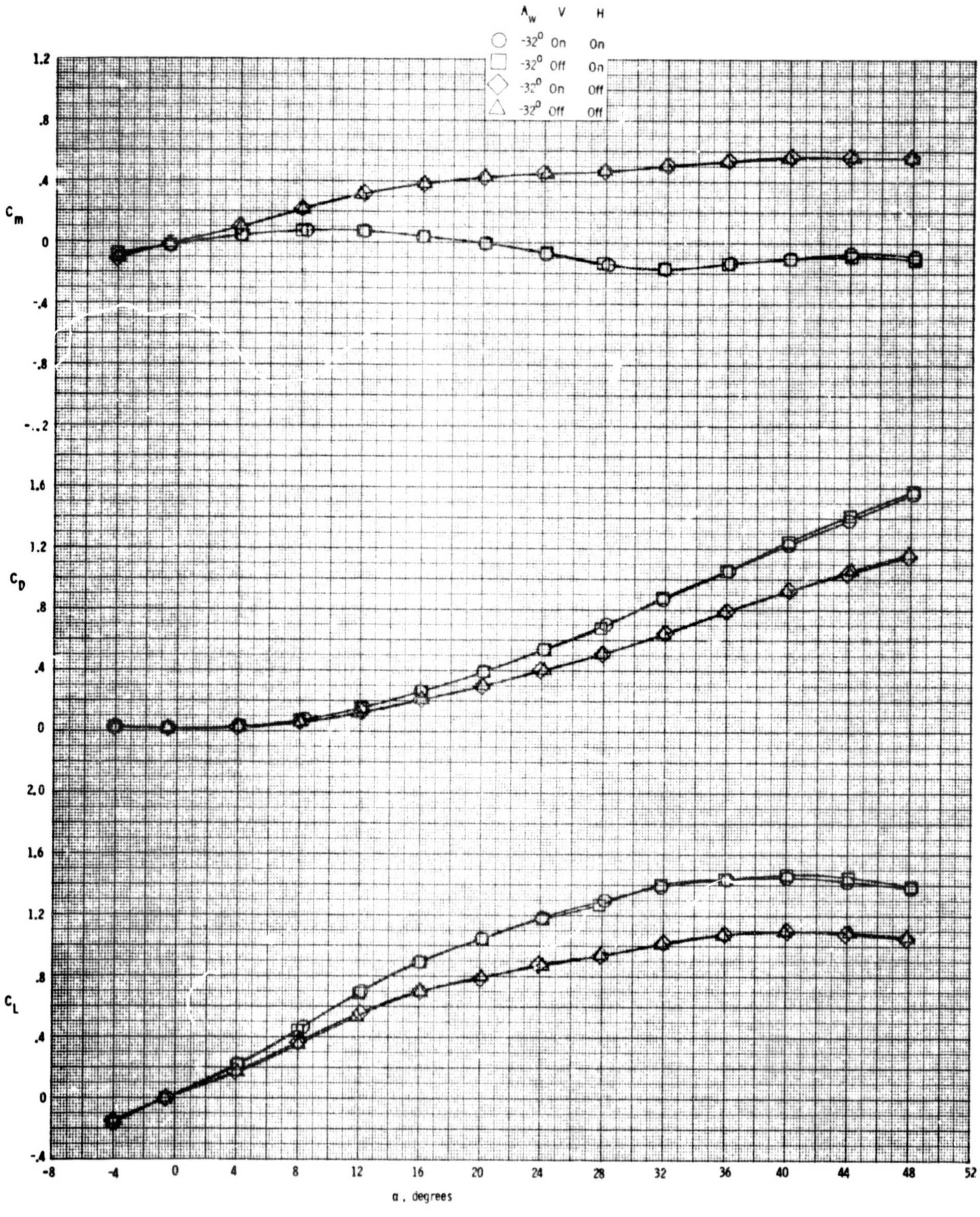
(a) Longitudinal characteristics

Figure 5. Characteristics of the swept forward configuration with the strake off. $M = 0.3$, $\beta = 0^0$.



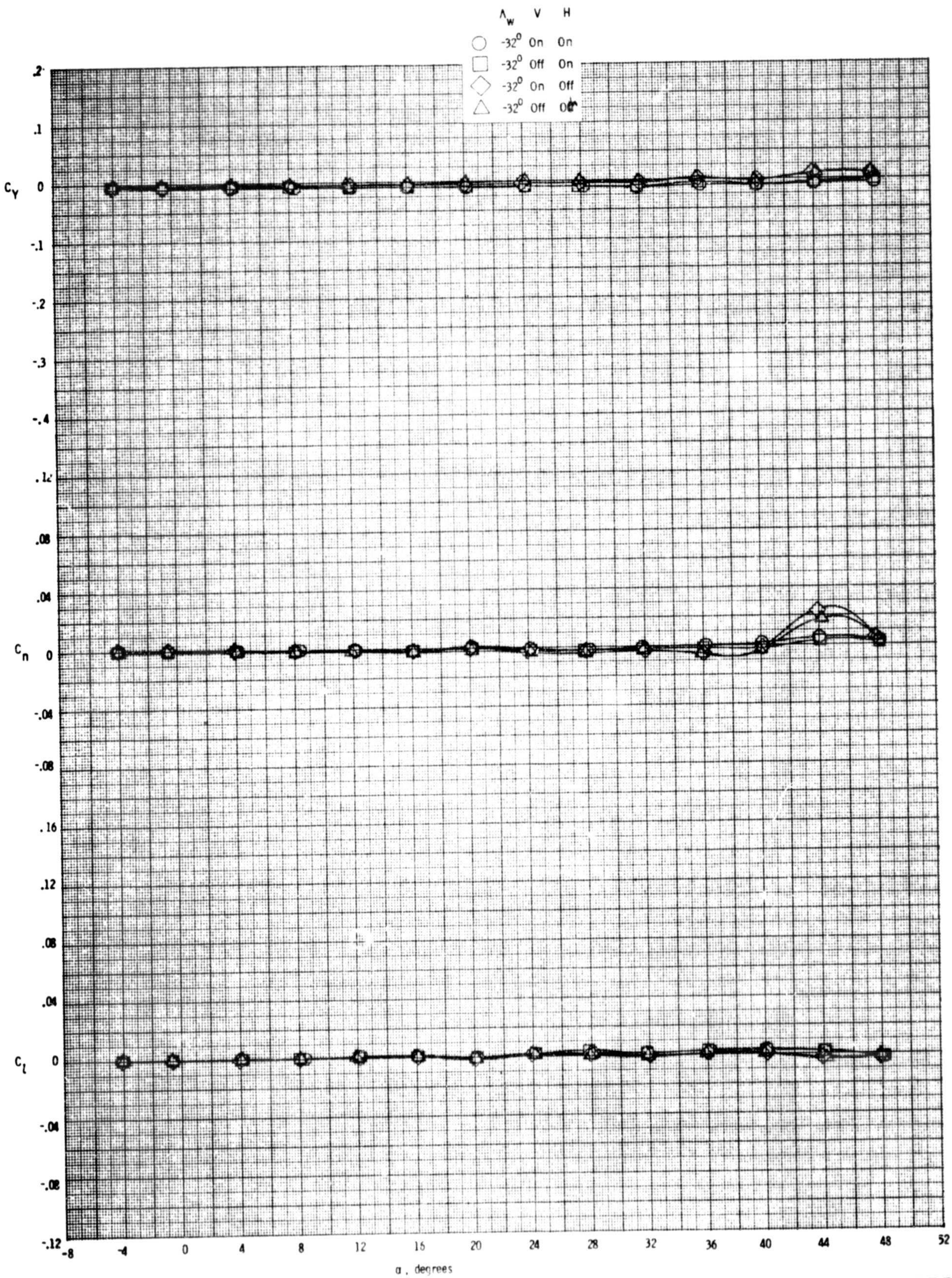
(b) Lateral-directional characteristics

Figure 5. Concluded.



(a) Longitudinal characteristics

Figure 6. Characteristics of the swept forward configuration with the strake on. $M = 0.3$, $\beta = 0^{\circ}$.



(b) Lateral-directional characteristics

Figure 6. Concluded.

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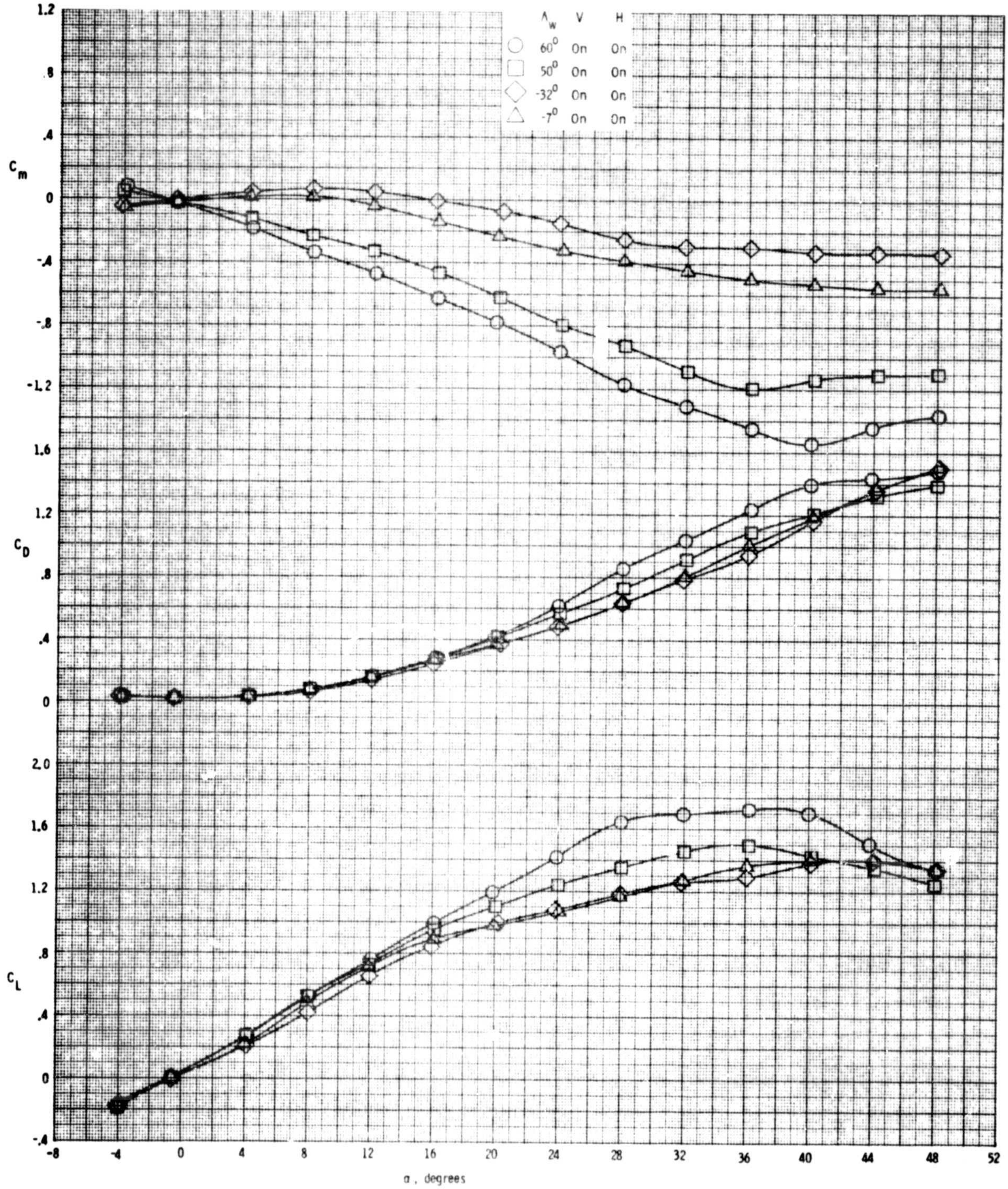
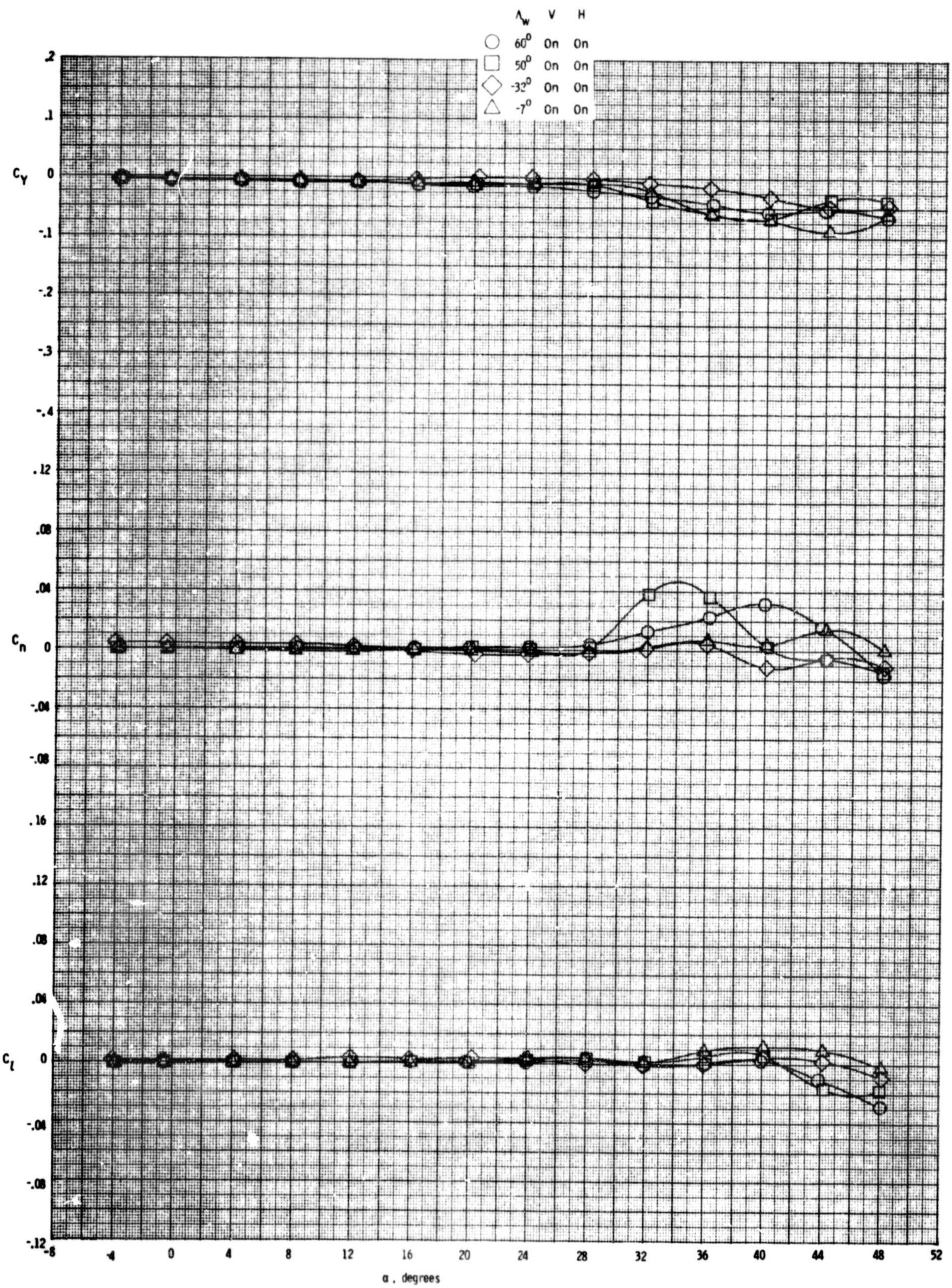


(a) Longitudinal characteristics

Figure 7. Characteristics as a function of sweep. $M = 0.3$, $\beta = 0^0$.



(b) Lateral-directional characteristics

Figure 7. Concluded.

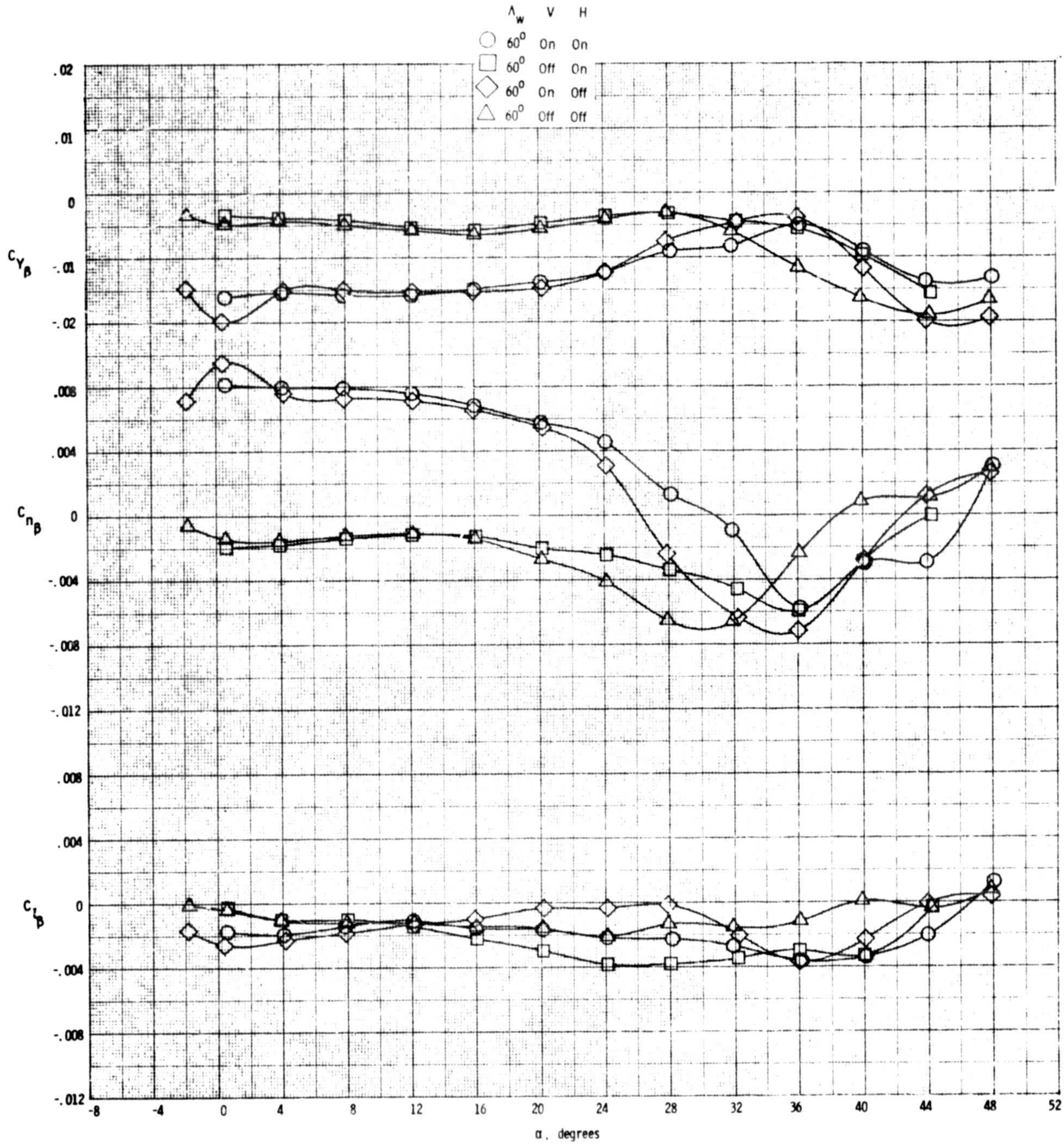


Figure 8. - Lateral-directional aerodynamic stability derivative characteristics of the swept back configuration. M = 0.3.

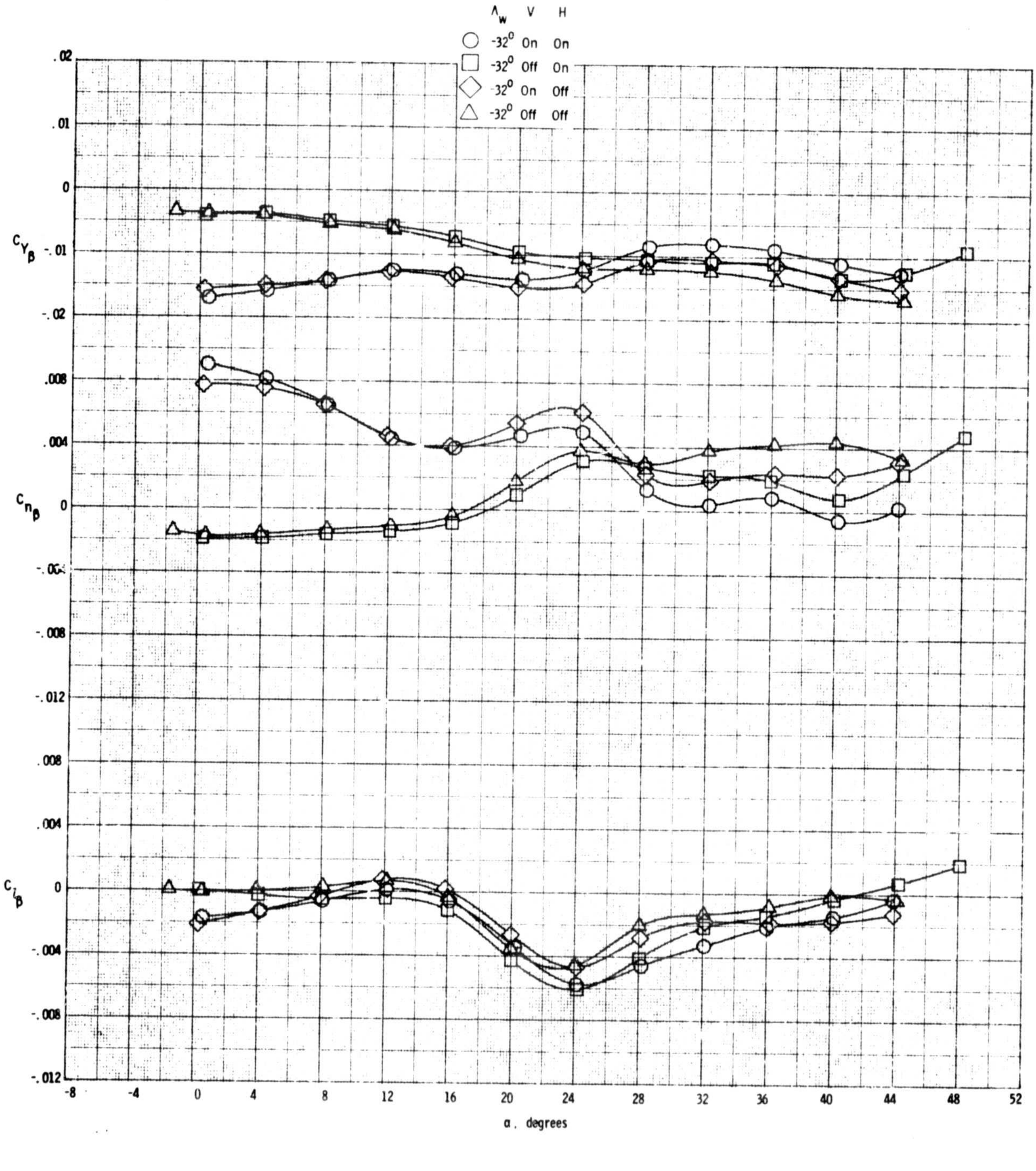


Figure 9. - Lateral-directional aerodynamic stability derivative characteristics of the swept forward configuration with strake off. M = 0.3.

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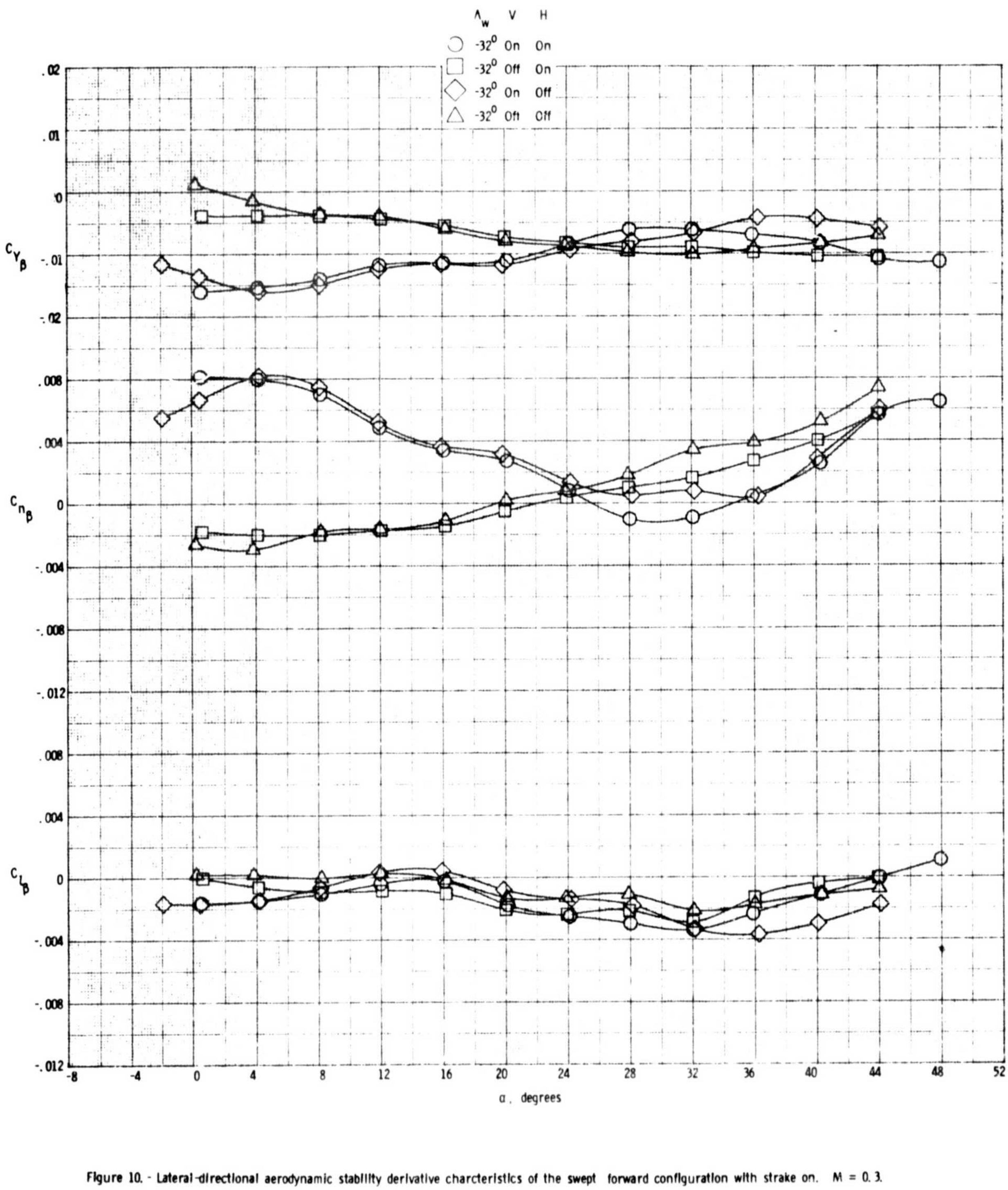

Figure 10. - Lateral-directional aerodynamic stability derivative charcteristics of the swept forward configuration with strake on. M = 0.3.

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16. Abstract

A general research fighter model was tested in the Langley 7- by 10-foot high speed tunnel at a Mach number of 0.3. With a conventional empennage, the model was tested with the wing in a 60° swept back configuration and in a 32° swept forward configuration. The 32° swept forward configuration was also tested with a strake. Very limited data was obtained with a wing in a 50° swept back configuration and in a 7° swept forward configuration. The angle-of-attack range was from approximately -4° to 48° at sideslip angles of 0°, -5°, and 5°. The data are presented without analysis in order to expedite publication.

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